SC9000 EP Medium Voltage Drives

User Manual

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Powering Business Worldwide

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Cover Photo: SC9000 EP Medium Voltage Drives

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Safety

Definitions and Symbols

WARNING

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

This symbol is the "Safety Alert Symbol." It occurs with either of two signal words: CAUTION or WARNING, as described below.

WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

Hazardous High Voltage

WARNING

Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

Warnings and Cautions

This manual contains clearly marked cautions and warnings which are intended for your personal safety and to avoid any unintentional damage to the product or connected appliances.

Please read the information included in cautions and warnings carefully.

Warnings

WARNING

Be sure to ground the unit following the instructions in this manual. Ungrounded units may cause electric shock and/or fire.

WARNING

This equipment should be installed, adjusted, and serviced by qualified electrical maintenance personnel familiar with the construction and operation of this type of equipment and the hazards involved. Failure to observe this precaution could result in death or severe injury.

WARNING

Components within the SC9000 EP power unit are live when the drive is connected to power. Contact with this voltage is extremely dangerous and may cause death or severe injury.

WARNING

Line terminals (L1, L2, L3), motor terminals (U, V, W) and the DC-link terminals (-/+/N) are live when the drive is connected to power, even if the motor is not running. Contact with this voltage is extremely dangerous and may cause death or severe injury.

WARNING

Even though the control I/O-terminals are isolated from line voltage, the relay outputs and other I/O-terminals may have dangerous voltage present even when the drive is disconnected from power. Contact with this voltage is extremely dangerous and may cause death or severe injury.

WARNING

The SC9000 EP drive has a large capacitive leakage current during operation, which can cause enclosure parts to be above ground potential. Proper grounding, as described in this manual, is required. Failure to observe this precaution could result in death or severe injury.

WARNING

An upstream disconnect/protective device must be provided as required by the National Electrical Code (NEC). Failure to follow this precaution may result in death or severe injury.

WARNING

Before opening the SC9000 EP drive doors:

Open main disconnect switch on the SC9000 EP drive.

Wait a minimum of 5 (five) minutes after all the lights on the keypad are off. This allows time for the DC bus capacitors to discharge.

A hazard voltage may still remain in the DC bus capacitors even if the power has been turned off. While wearing proper PPE, open the doors to the drive. Locate the yellow shorting stick and ensure metal end of stick is grounded. Discharge both halves of DC bus utilizing grounding studs on the rectifier.

Failure to follow the above precautions may cause death or severe injury.

Cautions

CAUTION

Do not perform any meggar or voltage withstand tests on any part of the SC9000 EP drive or its components. Improper testing may result in damage.

CAUTION

Prior to any tests or measurements of the motor or the motor cable, disconnect the motor cable at the SC9000 EP output terminals (U, V, W) to avoid damaging the SC9000 EP during motor or cable testing.

CAUTION

Do not touch any components on the circuit boards. Static voltage discharge may damage the components.

CAUTION

Any electrical or mechanical modification to this equipment without prior written consent of Eaton will void all warranties and may result in a safety hazard in addition and voiding of the UL listing.

CAUTION

Prevent foreign material such as wire clippings or metal shavings from entering the drive enclosure, as this may cause arcing damage and fire.

CAUTION

Install the SC9000 EP drive in a well-ventilated room that is not subject to temperature extremes, high humidity, or condensation, and avoid locations that are directly exposed to sunlight, or have high concentrations of dust, corrosive gas, explosive gas, inflammable gas, grinding fluid mist, etc. Improper installation may result in a fire hazard.

Motor and Equipment Safety

CAUTION

Before starting the motor, check that the motor is mounted properly and aligned with the driven equipment. Ensure that starting the motor will not cause personal injury or damage equipment connected to the motor.

CAUTION

Set the maximum motor speed (frequency) in the SC9000 EP drive according to the requirements of the motor and the equipment connected to it. Incorrect maximum frequency settings can cause motor or equipment damage and personal injury.

CAUTION

Before reversing the motor rotation direction, ensure that this will not cause personal injury or equipment damage.

CAUTION

Make sure that no power correction capacitors are connected to the SC9000 EP output or the motor terminals to prevent SC9000 EP malfunction and potential damage.

CAUTION

Make sure that the SC9000 EP output terminals (U, V, W) are not connected to the utility line power as severe damage to the SC9000 EP may occur.

Chapter 1: Introduction

Purpose

This user manual covers the installation, operation, and maintenance of the SC9000 Encapsulated Powerpole (EP) Medium Voltage Adjustable Frequency Drive (AFD). It does not cover all possible contingencies, variations, and details that may arise during installation, operation, and maintenance of this equipment.

Application and Description

The Eaton SC9000 Encapsulated Powerpole (EP) provides adjustable frequency control and protection of medium voltage AC motors and equipment rated at 2400V, 3300V, and 4160V. The SC9000 EP is typically supplied as an integrated drive that includes an integrated drive isolation transformer. It can be supplied as a stand-alone drive or it can be directly connected to other Ampgard products in a configuration known as Ampgard Integrated Control-Gear.

The SC9000 EP is available in five frame sizes, dependent on horsepower and voltage. Frame A is the smallest at approximately 65 inches wide, Frame B is approximately 95 inches wide, Frame C is approximately 137 inches wide, Frame D is approximately 198 inches wide, and Frame E is approximately 222 inches wide. Frame A is shipped as a single unit, while Frame B typically consists of two shipping sections, Frame C and D of three shipping sections, and Frame E or four shipping sections. The drive consists of several main components mounted together in the drive enclosure(s). Incoming cable or bus is fed through an incoming section that includes a non-load break isolation switch, current limiting power fuses, and a main vacuum contactor. The isolation switch can be opened to allow access inside the drive for servicing or troubleshooting. DC bus capacitor charging is accomplished by use of a DC bus pre-charge circuit. The DC bus capacitors are charged before application of main power that limits the very high damaging inrush currents to the main rectifier bridge devices. When the proper DC bus voltage is attained, the pre-charge circuit is turned off. The 24-pulse drive isolation transformer is connected after the pre-charge. Its output feeds into the rectifier. The rectifier powers the DC bus that in turn feeds the drive inverter. The inverter creates the adjustable frequency AC output that controls the speed of the connected motor. The inverter is a drawout truck-mounted device that can be withdrawn from the structure for repair or replacement. The inverter may feed an optional output filter that is supplied when the motor cable length is excessive.

Contact Eaton if the motor cable length is greater than what is recommended in Chapter 2 of Appendix B and the optional output filter has not been supplied.

Control power transformers are supplied to provide 120V single-phase control power for the drive and 480V three-phase power to the blowers. The CPTs are connected after the isolation switch and main fuses and are thus energized any time the isolation switch is closed.

Cooling blowers are provided to exhaust hot air from the drive enclosure. Replaceable filters are provided in the lower portion of the drive doors to minimize dust accumulation inside the enclosure.

Other standard and optional devices are supplied with the drive. Refer to the specific order drawings supplied with the drive to determine which devices have been provided with your equipment.

Revision

May 2013 Revision.

Documentation Reference

For further information on installation and application, refer to the applicable technical data, publications, and/or industry standards. Download Eaton electronic information from www.eaton.com.

Eaton Contact Information

For the location of your nearest Eaton sales office or distributor, call toll-free 1-800-525-2000 or log on to www.eaton.com. Eaton's Electrical Services & Systems (EESS) can be reached at 1-800-498-2678.

Chapter 2: Safety

Precautions

There is a hazard of electric shock whenever working on or near electrical equipment. Turn off all power supplying the equipment before starting work. Lock out the disconnecting means in accordance with NFPA 70E,® "Electrical Safety Requirements for Employee Safety In the Workplace."

Where it is not feasible to de-energize the system, take the following precautions:

1. Instruct persons working near exposed parts that are or may be energized to use practices (including appropriate apparel, equipment and tools) in accordance with NFPA 70E.
2. Require persons working on exposed parts that are or may be energized to be qualified persons who have been trained to work on energized circuits.

Only qualified electrical personnel with training and experience with medium voltage equipment (>1000V) shall be permitted to work on this apparatus. They shall be familiar with the work to be performed, as well as industry and local safety procedures and standards.

In addition, this person should have the following qualifications:

1. Be trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.
2. Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established practices.
3. Be trained in rendering first aid.
4. Be knowledgeable with respect to electrical installation codes and standards, for example, the National Electrical Code® (NEC®).

Read and understand all instructions before attempting installation, operation, or maintenance of the medium voltage drive.

Disconnect all low and medium voltage power sources to the drive or the medium voltage control-gear before working on the equipment. Lockout procedures must be followed. Verify that the voltage has been removed. Observe all local and national codes and standards

Safety Features

The medium voltage drive has many safety features to help ensure the safety of operators and maintenance personnel. Incoming voltage is disconnected from the downstream portion of the circuit by the isolation switch in the incoming section of the drive. The isolation switch is interlocked with the medium voltage door in the incoming section to prevent access to the compartment before the switch is opened. The switch is interlocked with the main contactor to prevent opening the switch under load. The switch operating mechanism is also interlocked to prevent closing the switch with the door open. A viewing window is provided to verify the switch position before entering the medium voltage compartment. Other medium voltage doors are also interlocked to prevent access until the switch is open as well. Distinctive marking on back of switch assembly appears when shutter barrier is in position and starter is completely isolated from the line. Grounding clips provide a positive grounding of the SC9000 EP AFD and main fuses when the isolating switch is opened. High and low voltage circuits are compartmentalized and isolated from each other. The drawout isolation switch is easily removed by loosening two bolts in the back of the switch. The shutter remains in place when the switch is withdrawn (see Chapter 7). Grounding device is provided for shorting the DC bus to ground before entering the medium voltage compartments.

The operating mechanism has provision for lockout/tagout. All local and other procedures should be followed to ensure safe operation.

DC Link Capacitors

⚠ WARNING

High storage device, do not enter drive until capacitors have discharged.

The DC Link consists of a large, medium voltage capacitor bank charged to a maximum of 7500 Vdc for 4160V drives, 5940 Vdc for 3300 drives, and 4320 Vdc for 2400V drives. The capacitors require 5 minutes to discharge to 50 Vdc after the main contactor is opened. Verify on the keypad that the DC voltage has discharged before entering the compartment. Follow verification and grounding procedures before installing or servicing the equipment.

Grounding Practices

⚠ WARNING

The SC9000 EP must be solidly grounded.

The inverter must be grounded in accordance with Article 250 of the National Electrical Code or Section 10 of the Canadian Electrical Code, Part I. The grounding conductor should be sized in accordance with NEC Table 250.122 or CEC, Part I Table 16. The SC9000 EP is supplied with a ground bus that runs the length of the drive. **If the drive is shipped in sections, be sure that the ground bus connection splices are installed across all shipping splits.** This ground bus must be solidly connected to the building ground grid. The ground connection is required for proper drive operation. The ground connection is required for personal safety. THE METAL OF CONDUIT IS NOT AN ACCEPTABLE GROUND.

Chapter 3: Technical Data/Ratings

Identification

A rating nameplate is located on the door nearest isolation switch of each SC9000 EP AFD. The drive type and ratings as required by industry standards are contained on this nameplate. Also contained on this nameplate is the factory's general order number. This number should be given to the Eaton sales office if a question should arise concerning the equipment or if renewal parts are required.

⚠ WARNING

Exceeding the nameplate ratings of an SC9000 EP medium voltage drive may cause equipment damage, severe injury, or death. Do not apply an SC9000 EP beyond its nameplate ratings.

The SC9000 EP is rated for use at a specific motor voltage and current as well as for a particular duty cycle. Care must be taken to ensure that these ratings are not exceeded. Verify that motor full load amperes do not exceed the rating indicated on the drive nameplate. The variable torque duty cycle allows for 110% overload for 1 minute in each 10-minute period. The constant torque duty cycle allows for 150% overload for 1 minute in each 10-minute period. Consult the factory if other duty cycle drives are required. The higher rating will be specified on the drive's rating nameplate. Verify that the duty cycle indicated on the nameplate matches the application.

The SC9000 EP may be rated for use with Constant Torque or Variable Torque loads. Ensure that the load type as noted on the drive-rating nameplate correctly matches the application.

The standard SC9000 EP is designed for use with non-regenerative loads. Consult the factory if the SC9000 EP is to be used with regenerative loads.

If the motor will be operated at speeds below 50% of base speed, a motor overload relay may not protect the motor. An internal motor RTD may be required. Failure to observe this precaution could result in damage to the motor.

SC9000 EP Standard Features

- Delivers maximum benefits while being the smallest fully integrated medium voltage drive in the industry
- Precise control of medium voltage motors up to 6000 hp
- Fully integrated package with isolation switch, main contactor, 24-pulse phase shifting isolation transformer, rectifier and inverter. Current limiting fusses, contactor assembly, inverter assembly, and isolating switch assembly are easily removed from the enclosure; line and load terminals are completely accessible from the front
- Positive mechanical isolating switch with visible disconnect completely grounds and isolates the AFD from the line power with a mechanically driven isolation shutter, leaving no exposed high voltage
- Utilizes highly reliable Ampgard components such as a non-load break switch rated for 10,000 mechanical operations, an SL contactor with the highest interrupting rating in the industry at 8500A, EATON power fuses, and a low profile handle mechanism
- Utilizes the same keypad and programming software as the SPX9000 line of low voltage drives. This standardization translates into a reliable, easy-to-use system that does not require hours of learning new software
- The SC9000 EP's keypad offers a full view of the drive's inner workings. Customers can view and change parameters and monitor actual running values right from the keypad.
  In addition, the keypad's built-in upload and download capability makes programming the SC9000 EP a snap, thereby drastically cutting startup time
- Extensively tested, manufactured, and assembled to ISO® 9001:2000 certification standards
- Designed and constructed to exacting UL® certification standards for use in the most rigorous applications
- The SC9000 EP's integrated phase shifting isolation transformer / 24 pulse converter coupled to a three-level inverter topology assures minimum component usage and reduces output harmonics, delivering sine wave power to the motor. Heat pipe technology improves cooling efficiency and allows the SC9000 EP to run at reduced noise levels. Output filters may be required in some applications
- The encapsulated draw-out inverter employs a patented insulation system, which reduces the potential of environmental contamination of the drive electronics
- The SC9000 EP's specialized design and patented thermal management system yields the smallest footprint per hp in the industry as a fully integrated drive. This size benefit ensures installations in space limited electrical rooms, eliminating the need for additional cable and conduit installations, and in some cases, eliminating the need for additional feeders required by our competitors
- The SC9000 EP's modular roll-in roll-out inverter design significantly reduces Mean Time to Repair (MTTR), which means that the SC9000 EP is built for maximum uptime
- The test/burn-in procedure runs the drive for a minimum of seven hours before shipping. This allows problems to be detected and corrected before shipment. This process exceeds the new IEEE 1566 requirements of 4 hour minimum test/burn-in before shipment
- Gateway for multiple communication protocols allow easy communication with all commonly used control systems, such as Modbus,® CANbus, PROFIBUS® DP, LonWorks,® CANopen, DeviceNet™
- System bus, CAN, for the networking of drives and peripherals

- Simple programming via a PC. The NCDrive software allows customers to upload and download drive parameters, which can be changed, saved, and transferred back to the drive and then printed or saved to a file for future reference. These parameters can also be compared to default values to determine drive configuration. Other operator functions include the ability to set references, start and stop the drive, and monitor and display signals and values. The NCLoad tool gives customers the ability to upload system, application, and option card software intended for engineering, commissioning, and service personnel
- Programmable for custom applications for control and I/O functions
- Low air volume displacement
- Low electrical noise
- Volts/hertz control for single or multiple motor applications
- Open-loop vector control
- Isolation with fiber optics
- Digital synchronization
- Integrated automation interface

Table 1. Specifications

Description		Value
Power rating		300–6000 hp (150–4313 kW)
Motor type		Induction and synchronous
Input voltage rating		2400–13,800V
Input voltage tolerance		±10% of nominal
Power loss ride-through		5 cycles (std.)
Input protection		Metal oxide varistor
Input frequency		50/60 Hz, ±5%
Input short-circuit current withstand		50 kA RMS SYM
Basic impulse level		60 kV
Input power circuit protection		Contactor/fuses
Input impedance device		Isolation transformer
Output voltage		0–2400V 0–3300V 0–4160V
Inverter design		PWM
Inverter switch		IGBT
Inverter switch failure mode		Opened
Inverter switch failure rate (FIT)		100 per one billion hours of operating time
Inverter switch cooling		Air-cooled
Inverter switching frequency		600 Hz
Number of inverter IGBTs	Voltage	Number of IGBTs
	2400V	12
	3300V	12
	4160V	12 ①
IGBT PIV rating (peak inverse rating)	Voltage	PIV Rating
	2400V	3300V
	3300V	6500V
	4160V	6500V
Rectifier designs		24-pulse PWM
Rectifier switch		Diode
Rectifier switch failure mode		Non-rupture, non-arc
Rectifier switch failure rate (FIT)		500 per one billion hours of operating time
Rectifier switch cooling		Air-cooled

Table 1. Specifications, Continued

Description	Value	
Number of rectifier devices	Voltage	Number of Diodes
	2400V	24
	3300V	24
	4160V	24
Diode PIV rating (peak inverse rating)	Voltage	PIV Rating
	2400V	4000V
	3300V	4000V
	4160V	4000V
Output waveform to motor	Sinusoidal current	
Medium voltage isolation	Fiber-optic	
Control method	V/Hz; sensorless vector; closed-loop	
	Fully digital signal processor	
	Pulse width modulated (PWM) output	
Speed regulation	0.1% without tachometer feedback	
Output frequency range	0–120 Hz	
Service duty rating	Standard	Optional
	110% overload for 1 minute every 10 minutes (variable torque load)	150% overload for 1 minute every 10 minutes (constant torque load)
Typical efficiency	96%–97%	
Input power factor	> 0.96	
Meet IEEE 519 harmonic guidelines	Yes	
Noise level	< 75 dB (A)	
Flying start capability	Yes—able to start into and control a spinning load in	
	Forward or reverse direction	
Local interface	Removable graphical backlit LCD and keypad	
	RS-232 connection for PC control	
Keys	Local/Remote, Start/Stop, Reset, Enter, Up/Down, Forward/Back	
Indicators	LCD: Local/Remote, Fault, Door: Contactor open/closed, Fault, Run status / DC bus	
Inputs/outputs	6 DI / 6 DO, 2AI / 1AO, 1 + 10 Vdc reference	
	2 Ext + 24 Vdc standard	
Enclosure	NEMA 1, Gasketed and Filtered; IP20	
Ambient temperature (without derating)	0°C to 40°C (32°F to 104°F)	
Storage and transportation temperature range	–40°C to +70°C (–40°F to +185°F)	
Relative humidity	95% non-condensing	
Altitude (without derating)	0 to 3300 ft (0 to 1000m)	
Seismic	2006 IBC	
Vibration	10–50 Hz, 0.5G or less	
Standards	NEMA, cUL, UL, ANSI, IEEE	
Cooling	Air-cooling advanced heat pipe technology	
Average watts loss ②	25 watts/hp	

① 24 IGBTs are required for motors above 3500 hp.
② Reflects conservative estimate. Actual amounts may vary.

Table 2. Power Specifications

Voltage Class

2400															
Drive rating (A)	69	80	91	103	114	134	156	178	201	223					
2400 drive output (kVA)	287	333	378	428	474	557	648	740	836	927					
Nominal hp 2400V	300	350	400	450	500	600	700	800	900	1000					
Frame size	Frame A					Frame B									
2400															
Drive rating (A)	279	335	390	448	504	561									
2400 drive output (kVA)	1160	1393	1621	1862	2095	2332									
Nominal hp 2400V	1250	1500	1750	2000	2250	2500									
Frame size	Frame C			Frame D											
3300															
Drive rating (A)	48	56	64	72	80	96	112	128	144	160	200	240	280	320	
3300 drive output (kVA)	274	320	366	412	457	549	640	732	823	915	1143	1372	1600	1829	
Nominal hp 3300V ①	300	350	400	450	500	600	700	800	900	1000	1250	1500	1750	2000	
Frame size	Frame A							Frame B					Frame C		
3300															
Drive rating (A)	360	400	440	480	520	560	600	640							
3300 drive output (kVA)	2058	2286	2515	2744	2972	3201	3429	3658							
Nominal hp 3300V ①	2250	2500	2750	3000	3250	3500	3750	4000							
Frame size	Frame D				Frame E										
4160															
Drive rating (A)	38	44	51	57	63	76	89	101	114	124	140	155	186	217	248
4160 drive output (kVA)	274	317	367	411	454	548	641	728	821	893	1008	1117	1340	1564	1787
Nominal hp 4160V	300	350	400	450	500	600	700	800	900	1000	1150	1250	1500	1750	2000
Frame size	Frame A											Frame B			
4160															
Drive rating (A)	279	310	341	372	403	434	461	493	527	558	589	620	651	682	713	744
4160 drive output (kVA)	2010	2234	2457	2680	2903	3127	3321	3552	3797	4021	4244	4467	4690	4914	5137	5360
Nominal hp 4160V	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
Frame size	Frame C				Frame D						Frame E					

Note

① Contact factory.

Table 3. Dimensions

Output Voltages	Motor FLA	HP	Cabinet Size (Inches) Width	Height	Depth	Redundant Blower Additional Height
Frame A						
2400	69–114	300–500	65	92	50	18.5
3300 ①	48–112	300–700	65	92	50	18.5
4160	38–140	300–1150 ②	65	92	50	18.5
Frame B						
2400	134–223	600–1000	95	92	50	20.1
3300 ①	128–240	800–1500	95	92	50	20.1
4160	155–248	1250–2000	95	92	50	20.1
Frame C						
2400	279–390	1250–1750	131	92	50	12.25
3300 ①	280–320	1750–2000	131	92	50	12.25
4160	279–372	2250–3000	137	92	50	12.25
Frame D						
2400	448–561	2000–2500	172	92	50	20.1
3300 ①	360–480	2250–3000	172	92	50	20.1
4160	403–558	3250–4500	222	92	50	20.1
Frame E						
3300 ①	520–640	3250–4000	222	92	50	20.1
4160	589–744	4750–6000	246	92	50	20.1

Notes

① Contact factory.

② Contact factory for 1150 hp.

Chapter 4: Handling, Storage and Installation

General Information

Medium-voltage drives are extremely heavy and the moving equipment used in handling must be capable of supporting the weight of the drive. Confirm this capability prior to starting any handling operations with the drive. Refer to the charts below for standard SC9000 EP shipping section weights. These weights are approximate. Refer to the job specific drawings for the weights of each shipping section.

⚠ WARNING

Tall structure—may tip over if mishandled. May cause bodily injury or equipment damage. Do not remove from skid until ready to secure in place. Read handling instructions below before moving.

The drive should be kept in an upright position. If the equipment is received in the horizontal position, notify the carrier of possible damage, and restore the drive to the vertical position as soon as practicable.

Upon receipt, immediately inspect the drive for any signs of visible or concealed damage that might have occurred during shipment. If damage is found, it should be noted with the carrier prior to accepting the shipment, if possible. Carefully unpack the equipment sufficiently to check for concealed damage. Verify that there are no bent, broken or loose components. Review the drive nameplate to ensure that the marked ratings match the order specifications.

Table 4. 2400V AFD Typical Shipping Section Weights (Lbs)

		Shipping Sections				
Frame	**hp**	**Transformer**	**Inverter**	**Main Disconnect**	**Incoming**	**Total**
A	300	5825	—	—	—	5825
	350	5925	—	—	—	5925
	400	6025	—	—	—	6025
	450	6225	—	—	—	6225
	500	6425	—	—	—	6425
B	600	5785	1440	—	—	7225
	700	6135	1440	—	—	7575
	800	6485	1440	—	—	7925
	900	6785	1540	—	—	8325
	1000	7385	1540	—	—	8925
C	1250	7785	1540	600	—	9925
	1500	8385	1740	600	—	10,725
	1750	8785	1840	600	—	11,225
D	2000	9035	2240	1550	1000	13,825
	2250	10,135	2340	1550	1000	15,025
	2500	11,235	2340	1550	1000	16,125

Table 5. 3300V AFD Typical Shipping Section Weights (Lbs)

		Shipping Sections					
Frame	**hp**	**Transformer**	**Inverter**	**Main Disconnect**	**Incoming**	**Converter**	**Total**
A	300	5825	—	—	—	—	5825
	350	5925	—	—	—	—	5925
	400	6025	—	—	—	—	6025
	450	6125	—	—	—	—	6125
	500	6225	—	—	—	—	6225
	600	6525	—	—	—	—	6525
	700	6825	—	—	—	—	6825
B	800	6185	1640	—	—	—	7825
	900	6535	1740	—	—	—	8275
	1000	6885	1740	—	—	—	8625
	1250	7285	1840	—	—	—	9125
	1500	8185	2240	—	—	—	10425
C	1750	8185	2340	1000	—	—	11525
	2000	9385	2440	1000	—	—	12825
D	2250	9235	3240	1550	1000	—	15025
	2500	10435	3340	1550	1000	—	16325
	3000	12235	4240	1550	1000	—	19025
E	3250–4000	18000	4500	1550	1000	1000	26050

Table 6. 4160V AFD Typical Shipping Section Weights (Lbs)

		Shipping Sections					
Frame	**hp**	**Transformer**	**Inverter**	**Main Disconnect**	**Incoming**	**Converter**	**Total**
A	300	5525	—	—	—	—	5525
	350	5625	—	—	—	—	5625
	400	5725	—	—	—	—	5725
	450	5925	—	—	—	—	5925
	500	5925	—	—	—	—	5925
	600	6225	—	—	—	—	6225
	700	6525	—	—	—	—	6525
	800	6875	—	—	—	—	6875
	900	7325	—	—	—	—	7325
B	1000	6685	1640	—	—	—	8325
	1250	7135	1640	—	—	—	8775
	1500	7785	1740	—	—	—	9525
	1750	8285	1740	—	—	—	10025
	2000	9285	2140	—	—	—	11425
C	2250	9885	2240	1000	—	—	13125
	2500	10885	2240	1000	—	—	14125
D	3000	12385	2740	1550	1000	—	17125
	3500	12935	3440	1550	1000	—	18375
	4000	13385	3540	1550	1000	—	18925
	4500	13885	3740	1550	1000	—	19625
	5000	14385	3840	1550	1000	—	20225
E	4750–6000	18000	4500	1550	1000	1000	26050

Lifting Equipment List

- Overhead lifting of transformer shipping section:
  - Crane of adequate load rating (refer to **Tables 4**, **5** and **6**)
  - Spreader bar of adequate load rating
  - Optional overhead lifting cradle kit
  - Lifting chains, cables or slings of adequate load rating
  - Safety hooks or shackles of adequate load rating
- Overhead lifting of input and inverter shipping sections:
  - Crane of adequate load rating (refer to **Tables 4**, **5** and **6**)
  - Lifting chains, cables or slings of adequate load rating
  - Safety hooks or shackles of adequate load rating
- Fork truck lifting transformer shipping section (required for FRAME E transformer shipping section and optional for other sections)
  - Fork truck of adequate load rating (refer to **Tables 4**, **5** and **6**)
  - Safety strap

Receiving Check List

1. _____ Inspect the unit for any signs of shipping damage.
2. _____ Check the job specific drawings for the actual weights of each shipping section. Verify that all handling equipment is of adequate load rating to lift the shipping sections.
3. _____ Review the drive nameplate and verify that the information on the nameplate matches the rating specified on the order.
4. _____ Open all doors and inspect equipment for any bent, broken or loose components.

Long-Term Storage

If it is necessary to store an SC9000 EP AFD before installation, restore the protective packaging for the storage period and keep it in a clean, dry location with ample air circulation and heat to prevent condensation. Like all electrical apparatus, an SC9000 EP contains insulation and electrical components that must be protected against dirt and moisture.

Storage temperature: –20°C to +65°C.

Handling

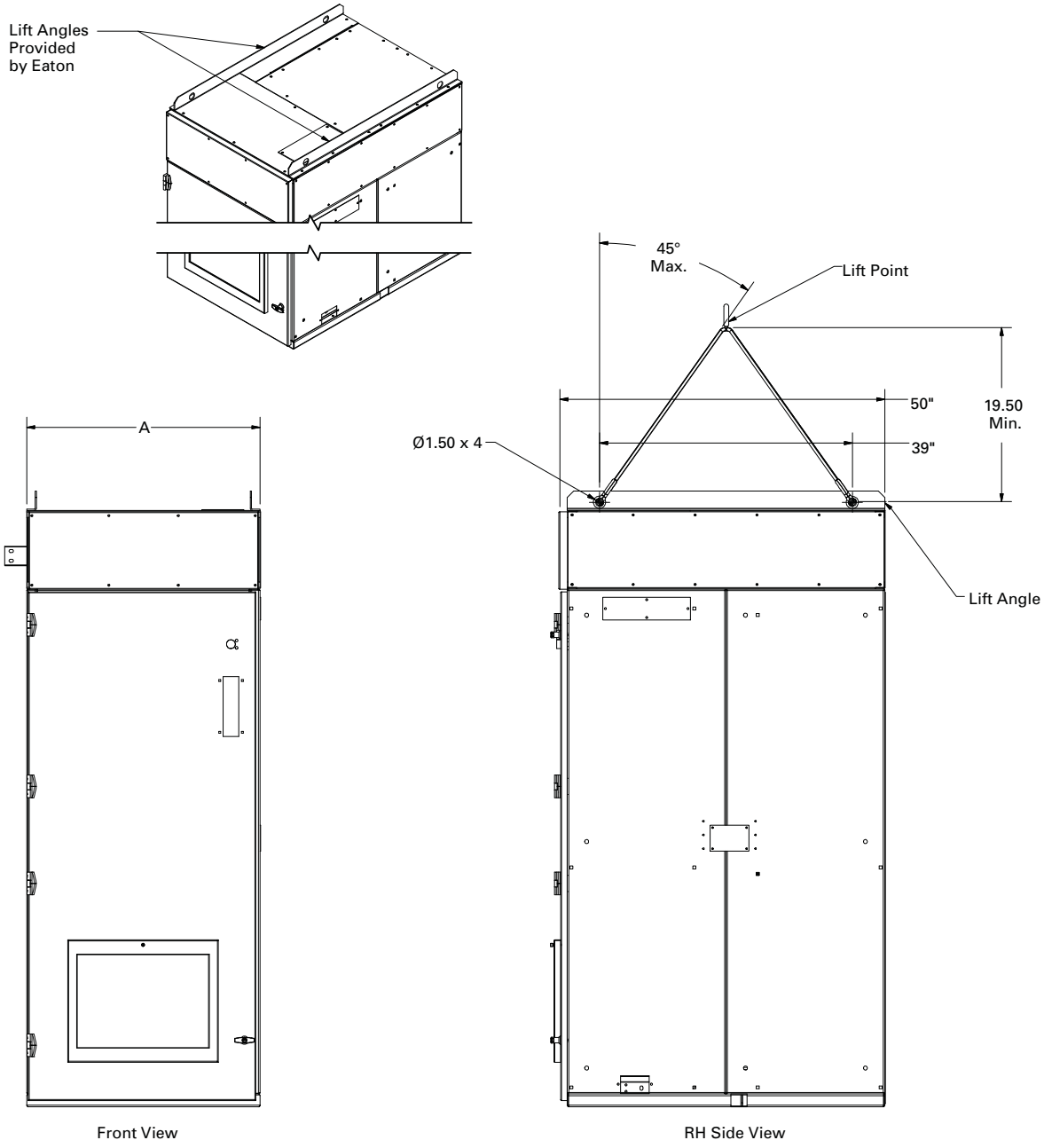
Exercise extreme care during any movement and placement operations to prevent dropping or unintentional rolling or tipping. The preferred method of handling is by crane or forklift. See **Figure 4** and for instructions on lifting the drive shipping sections by crane. The drive shipping sections contain heavy equipment, such as transformers, that can make the center of gravity vary considerably from the center of the cabinet. Verify that the capacity of the crane is not exceeded by the weight of the section being lifted.

- Select or adjust the rigging lengths to compensate for any unequal distribution of load, and to maintain the shipping section in an upright position. Some shipping section interiors may contain heavy equipment that can make the center of gravity be considerably off
- Do not allow the angle between the lifting cables and vertical to exceed 45 degrees
- Do not pass ropes or cables through the lift holes
- Use slings with safety hooks or shackles of adequate load rating
- Avoid pinch points

Refer to the job specific drawings for the diagrams showing the proper lifting points of each shipping section.

The shipping section that contains the transformer can alternatively be lifted by fork truck. The channels for lifting by the fork truck can be exposed by removing the panel at the front bottom of the shipping section. Verify that the fork truck rating is not exceeded by the weight of this section. A safety strap should be used when handling with a forklift. Do not allow an end of a fork to enter the bottom of an open bottom enclosure. Refer to **Tables 4**, **5** and **6** for the weights of each shipping section.

Figure 1. Frame B Inverter Section, Frame C Main Disconnect and Inverter Sections, Frame D Main Disconnect, and Inverter Sections, Frame E Main Disconnect Section, and Filters



"A" Width Dimensions

Frame C/D/E incoming	36 inches
dV/dt filters up to 500 hp	24 inches
Frame B/C/D inverter	30 or 36 inches
dV/dt filters 600 to 2500 hp	36 inches
Output reactors and sine filters	40 inches

Figure 2. Frame A Drive and Frame B Transformer Section Overhead Lifting

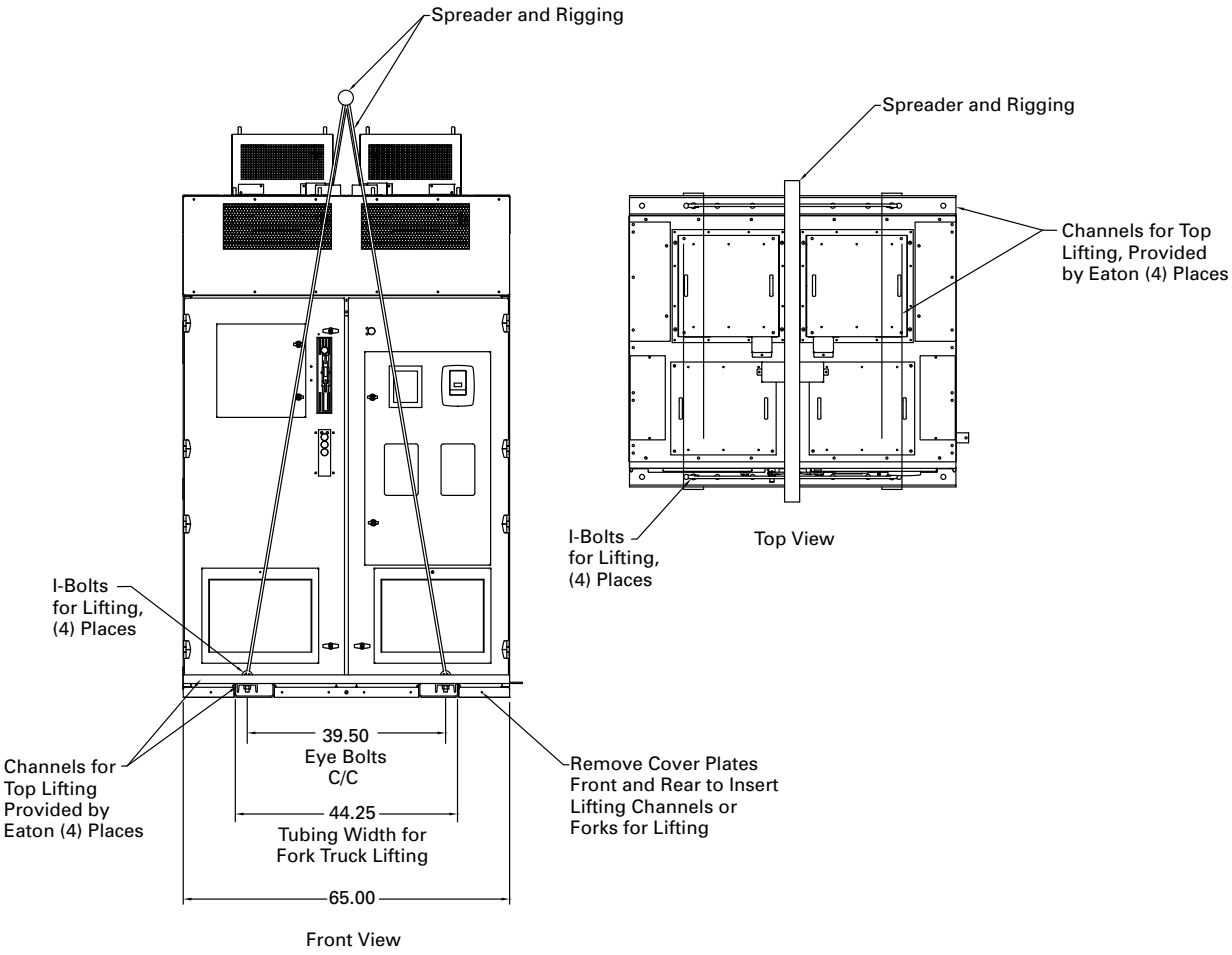
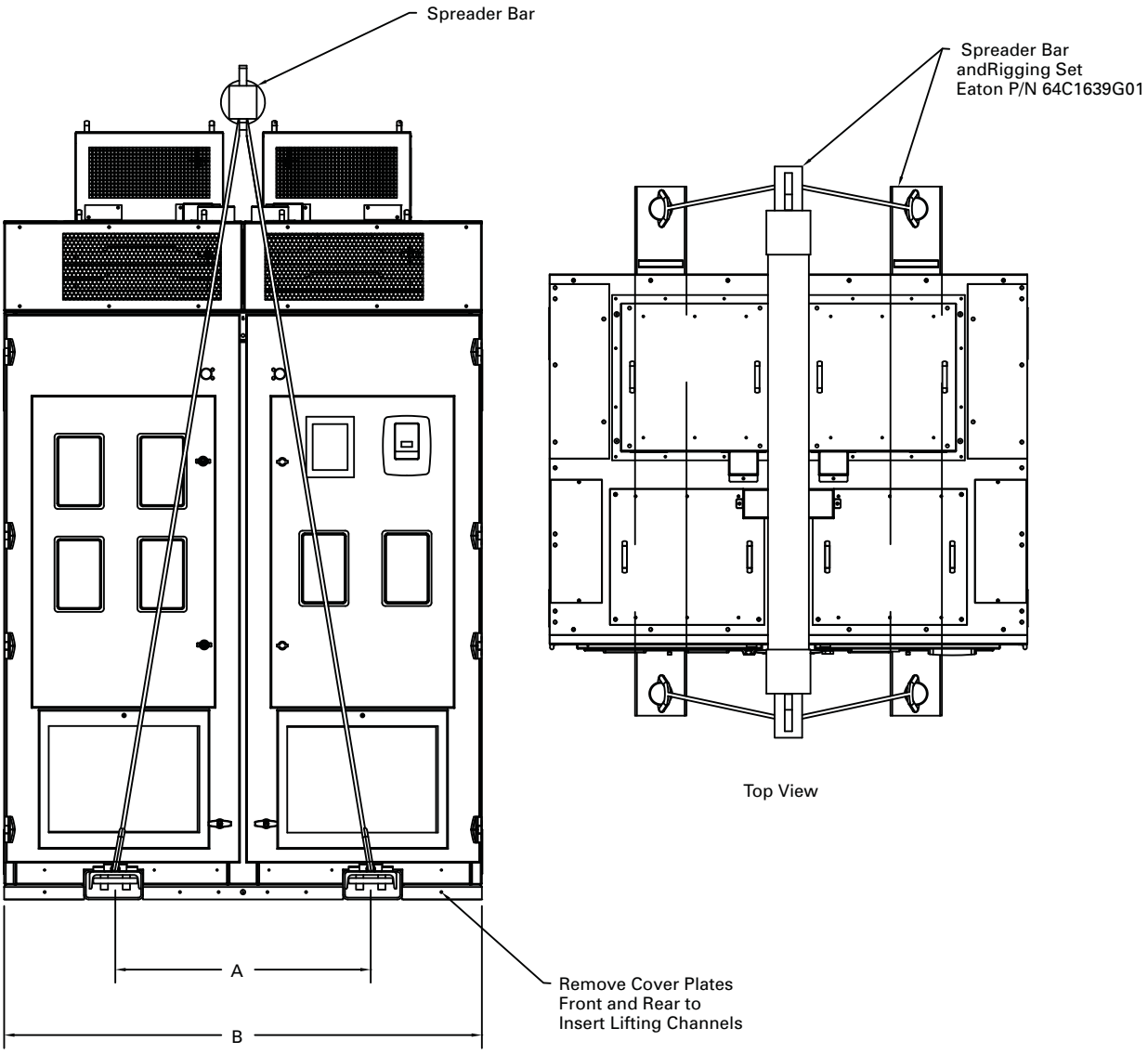

Spreader and Rigging
Spreader and Rigging
Channels for Top Lifting, Provided by Eaton (4) Places
I-Bolts for Lifting, (4) Places
Top View
I-Bolts for Lifting, (4) Places
Channels for Top Lifting Provided by Eaton (4) Places
39.50 Eye Bolts C/C
44.25 Tubing Width for Fork Truck Lifting
65.00
Remove Cover Plates Front and Rear to Insert Lifting Channels or Forks for Lifting
Front View

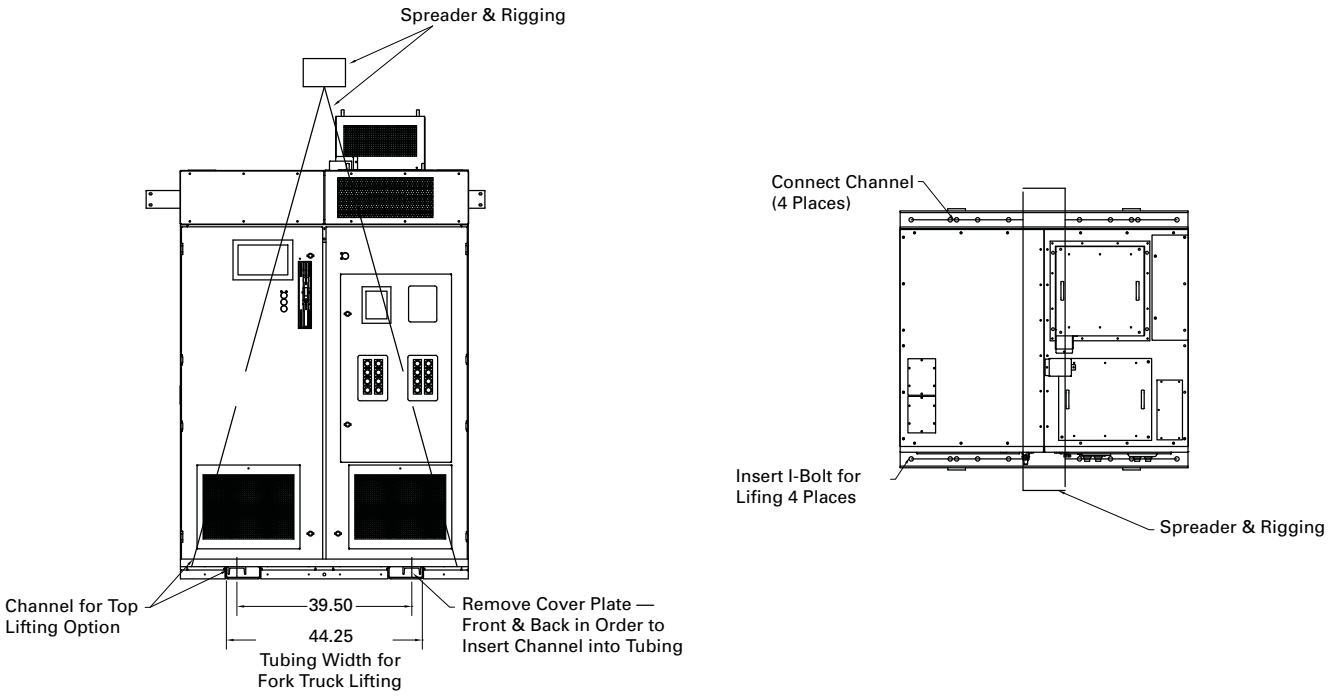
Figure 3. Frame C, Frame D, and Frame E Transformer Section Overhead Lifting



A and B Dimensions

Unit	A Dimension	B Dimension
Frame C converter	34.75 inches	65 inches
Frame D converter	40.5 inches	76 inches
Frame E converter	50 inches	100 inches

Figure 4. Frame A Drive and Frame B/C Transformer Section Overhead Lifting



Transformer Cabinet Lifting Details – B Frame

Installation

Site Preparation

Complete the site preparation before the drive is unpacked, so that possible problems, such as headroom, conduit location, cable tray locations, ventilation, etc., can be solved, ensuring a safe installation, in compliance with the building plans and codes. Verify that conduit locations are compatible with the available area shown on the order drawings.

Make the intended mounting surface level so that the drive is not distorted when bolted into place. Check the overhead for plumbing condensation, sprinklers or similar possible sources of trouble and take corrective steps where necessary.

Provide for adequate grounding connections to be made in accordance with applicable code requirements.

If plans call for bottom conduit entry, conduits must be placed in locations where there is adequate clearance for conduit bushings. See the outline drawings for the order. Available space for top and bottom conduit entry is order specific.

General Information

The SC9000 EP is designed to be installed, operated and maintained by adequately trained and qualified personnel. These instructions do not cover all details, variations or combinations of the equipment, its storage, delivery, installation, check-out, safe operation or maintenance. The required electrical connections are shown on the order-specific wiring diagram shipped with each controller. Comply with local, state and national regulations, as well as safety practices, for this class of equipment. The drive is designed for front access, meaning that it can be installed directly against a wall to the rear and/or either side. Sufficient space must be allowed in front of the drive for installation, troubleshooting and maintenance access. In general, 60 inches of clearance must be allowed. See Appendix A for diagrams showing standard space requirements and door swing for each frame size. Job specific drawings should be checked for any variation from the standard.

Mounting

After the drive/lineup has been placed in position, anchor bolts should be installed and tightened in the floor of the enclosure. See Appendix A for diagrams showing standard bolt locations for each frame size and provisions for seismic-resistant mounting. Job specific drawings should be checked for any variation from the standard. The use of 1/2 inch diameter bolts is recommended. When a drive/lineup includes two or more shipping sections, the order outline drawing will show the sequence in which the sections are to be lined up and which shipping splits are to be joined. A bus bar splice kit (where applicable) and a connecting hardware kit are supplied for each open joint between sections.

Redundant Blowers/Pull Box

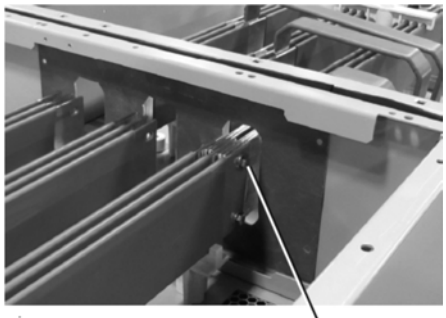
If the SC9000 EP drive has redundant blowers or a pull box for mating to an integrated control-gear lineup, they will be shipped loose due to carrier height restrictions. The Frame A would have one redundant blower assembly, Frame B/C would have two redundant blower assemblies, Frame D would have three to five redundant blower assemblies and the Frame E would have four to five redundant blower assemblies. These assemblies must be installed per the instructions shipped with the job specific drawings before commissioning the AFD.

SC9000 EP Unit Connection

Main Bus Connection

For units requiring main bus, connections to be made using 3/8-16 HHCS, flat washers, lock washers, and nut. Apply 18-25 ft-lb torque. Bus splice plates will be shipped connected to one end of the unit split (**Figure 5**).

Figure 5. Main Bus Splice

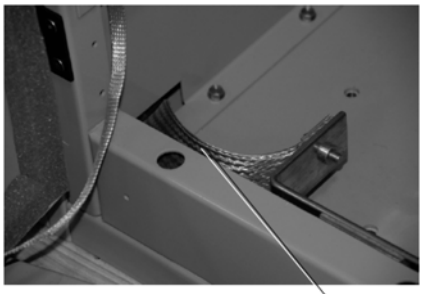


Main Bus Splice Between Unit Split

Ground Bus Connection

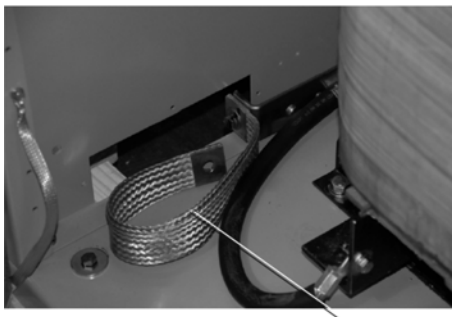
Ground bus is typically linked between units/splits using a braided flexible shunt (P/N 151B587G02). Ground bus links will be shipped connected to one end of the split (**Figures 6** and **7**). Connections to be made using 3/8-16 HHCS with flat and lock washer. Apply 18-25 ft-lb torque. In specific configurations hard bus links may be used, however hardware and torque values will be consistent.

Figure 6. Flexible Ground Bus Link



Shunt Passing Through Opening in Side Sheet

Figure 7. Flexible Ground Bus Link



Shunt Pre-Connected to One End of Split for Shipping

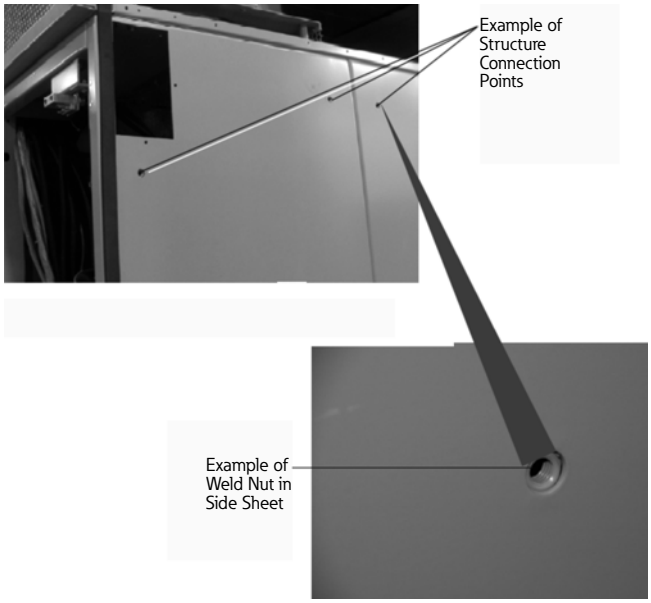
In drive-to-drive applications, the ground bus connection will generally be made through the forward most opening in the side sheet In rear aligned drive to Ampgard applications, the ground bus connection will be made through the central opening of the drive, while the forward opening is blanked by a cover plate (**Figure 8**).

Figure 8. Ground Bus Openings

Structure Connection

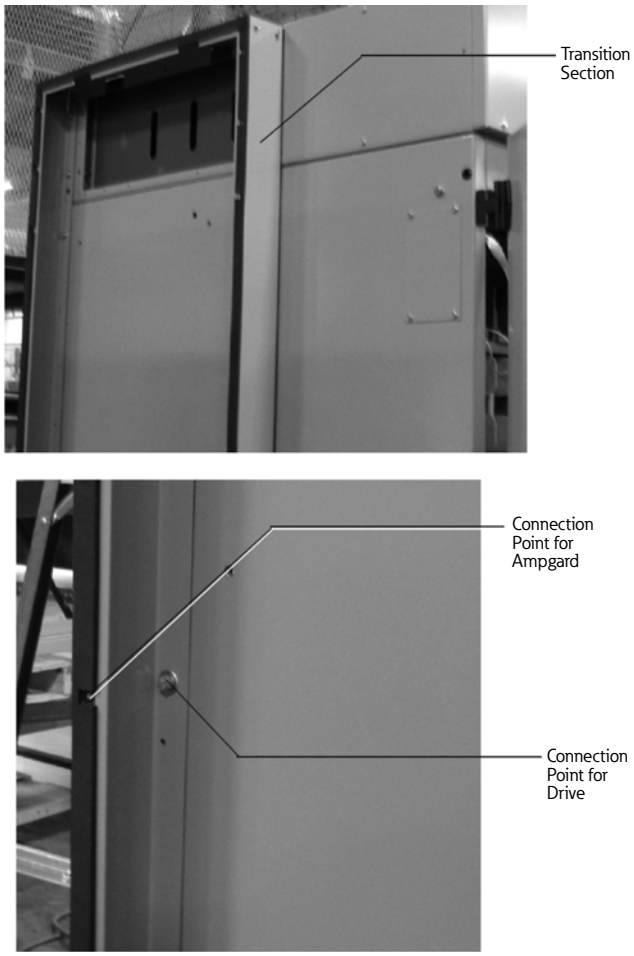
Drive-to-drive and shipping splits within a drive unit are directly coupled. One coupling method utilizes a side sheet with weld nut where the mating side sheet has a clearance hole. Other couplings use clearance holes in both mating sheets. In either case, 3/8-16 HHCS, flat washer, and lock washer are to be used and torqued to 18-25 ft-lb torque (**Figure 9**).

Figure 9. Structure Connection Detail



Drive units are secured to Ampgard units through the use of a transition section.In these applications, Tinnerman nuts are placed in the side sheet of the drive and the transition section is bolted to it using 3/8-16 HHCS with flat and lock washer. Tinnerman nuts (5/16-18) are also placed in the opposite flange (Ampgard side) of the transition section (**Figure 10**).

Figure 10. Transition Section



The Ampgard-Drive connection is made by passing hardware through the Ampgard side sheet (**Figure 11**) into the Tinnerman nuts of the transition and requires the use of 5/16-18 x 2 HHCS, (2) flat washers, lock washer, and spacer--Eaton PN 25A4184H01, 0.625OD x 0.328ID x 0.85 LGH and torqued to 10-14 ft-lb (**Figure 12**).

Figure 11. Transition Connection to Ampgard

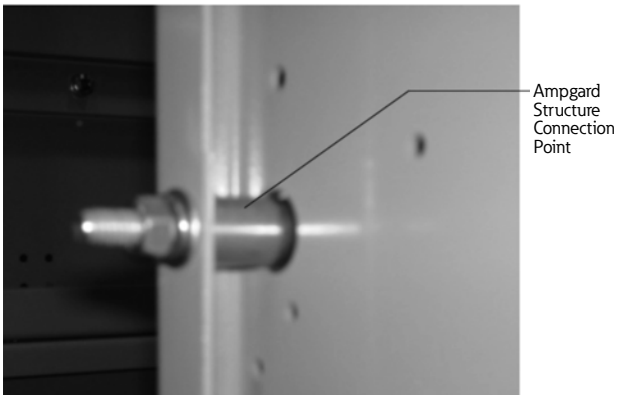
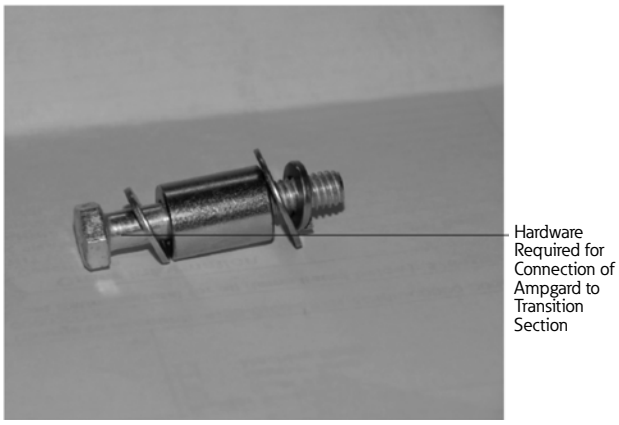


Figure 12. Hardware for Transition to Ampgard

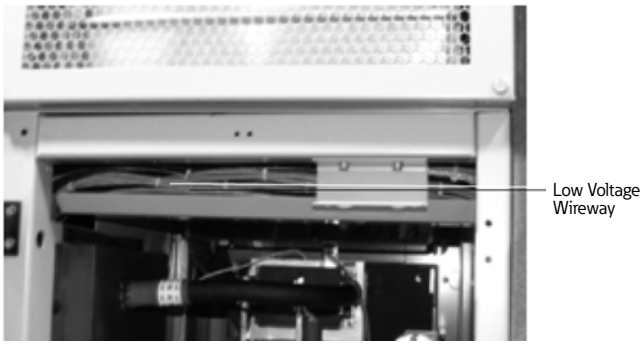


Low Voltage Connection

Low voltage pathways for drive-to-drive and shipping splits within a drive are located in the upper front area of the side sheet (**Figure 15**).Within the drive, low voltage cables are routed along the top front of the cabinet (**Figure 13**) and in some cases are nested in wireways (**Figure 14**).

Figure 13. Low Voltage Pathway

Figure 14. Low Voltage Wireway



Low voltage pathways between drives and Ampgard are most often located in the center of the drive side sheet (**Figure 15**). In each case, pull apart terminal blocks are the general method of providing breaks between units (**Figure 16**).

Figure 15. Low Voltage Pathway Between Splits

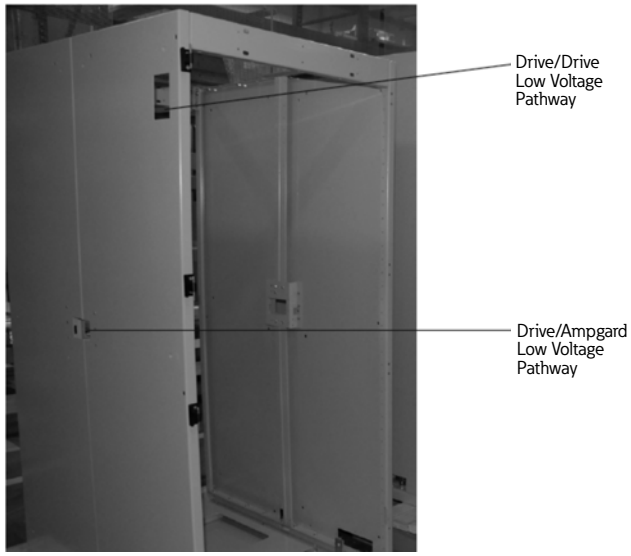
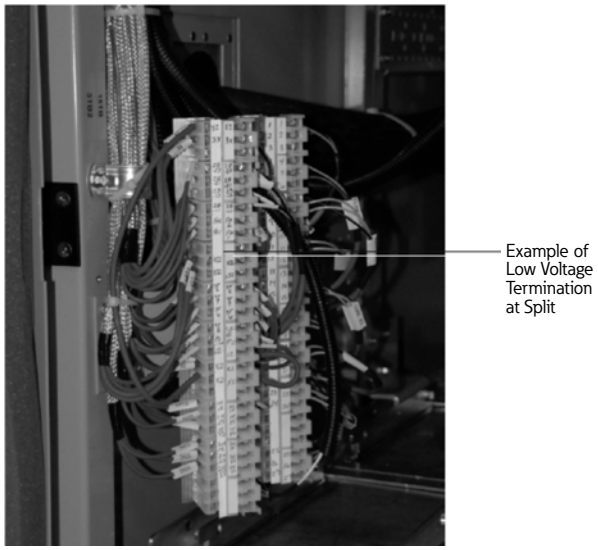


Figure 16. Low Voltage Termination at Split



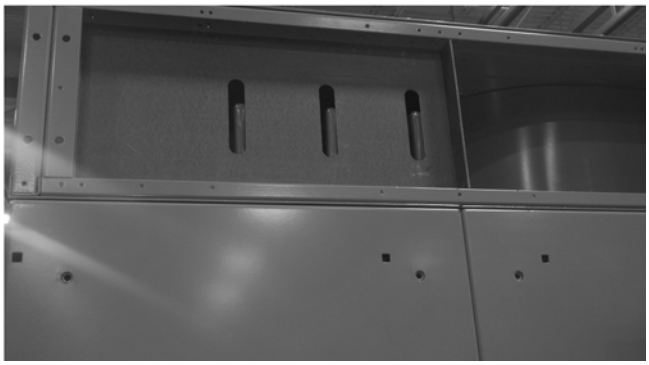
The order outline drawing will show the sequence in which the sections are to be joined. A bus bar splice kit and a connecting hardware kit is supplied for each open joint between sections.

Remove the bus compartment top cover plates from the two adjacent sections to be joined. Store lifting angles for possible future use. Also remove any knockouts in the side plates that will be used, e.g., for control cables.

Place the transformer shipping section into position. Move the inverter shipping split(s) into position alongside the first and use the 3/8 x 1.50 inch bolts and companion hardware to connect the two side plates. Place one flat washer under the bolt head and one flat washer and one lock washer under the nut. Tighten each bolt to 12 ft-lb (16 Nm). On Frame C, D, and E only, move the input shipping split into position alongside the first and use the 3/8 x 1.50 inch bolts and companion hardware to connect the two side plates. Place one flat washer under the bolt head and one flat washer and one lock washer under the nut. Tighten each bolt to 12 ft-lb (16 Nm).

Connect the main bus bars using the splice kit provided (where applicable). Tighten bolts to 25 ft-lb (33 Nm).

Figure 17. Main Bus Shipping Split Connection



Internal control wires and power cables will have to be connected across any shipping splits.

Standard connections across shipping splits for a Frame B drive are as described below (see Appendix A for section details):

- Ground Bus from Inverter section to Transformer section (Section 2 to 1)
- Power cables from DC Bus to line side bus of Inverter (Section 1 to 2)
- Power cables from drive output terminals to the load-side bus of inverter (Section 1 to 2)
- Fiber Optic cables from inverter to Control Card Rack (Section 2 to 1)
- Control wiring from Inverter to control compartment (Section 2 to 1)

Typical connections across shipping splits for a Frame C drive are as described below (see Appendix A for section details):

- Ground Bus from Inverter section to Transformer section and from Incoming section to Transformer Section (Section 3 to 2 and 1 to 2)
- Power cables from load side of main contactor to isolation transformer and precharge contactor (Section 1 to 2)
- Power cables from DC Bus to line side of Inverter (Section 2 to 3)
- Power cables from load side of inverter to the Drive output terminals; Both ends of cables must be connected (Sections 3 to 2 and 2 to 1)
- Fiber Optic cables from inverter to Control Card Rack (Section 3 to 2)
- Control wiring from Inverter to control compartment (Section 3 to 2)
- Control wiring from main contactor to control compartment (Section 1 to 2)

Typical connections across shipping splits for a Frame D and E drive are as described below (see Appendix A for section details):

- Ground Bus from Inverter section to Transformer section and from Incoming section to Transformer Section (Section 3 to 2 and 1 to 2)
- Power cables from load side of main contactor to isolation transformer and precharge contactor (Section 1 to 2)
- Power cables from DC Bus to line side of Inverter (Section 2 to 3)
- Fiber Optic cables from inverter to Control Card Rack (Section 3 to 2)
- Control wiring from Inverter to control compartment (Section 3 to 2)
- Control wiring from main contactor to control compartment (Section 1 to 2)

Refer to the order specific drawings for any additional wiring that must be connected across shipping splits.

Incoming Connections

Incoming power connects to the drive/lineup in a variety of ways. Cables, bus from other close-coupled equipment, bus duct, and transformer shunts are some of the more common methods. Note that these connections may be energized even when the drive isolation switch or other switching devices are in the open position.

⚠ WARNING

De-energize and lockout all incoming power connections, at their source before servicing any part of the equipment directly connected to the incoming power, including main horizontal bus, vertical bus, bus potential transformers or control power transformers.

See Appendix A for diagrams showing standard locations for incoming connections. Review the order drawings supplied with the equipment for information on the incoming terminal connections for your specific equipment.

Isolation panels must be removed to connect to the load and line terminals. These isolation panels must be installed in the original locations after making the load and line terminations.

Ensure that all connections are tight and of the proper ampacity to carry the rated load. Cables should be properly supported and braced, with special attention to ensure that the insulation is protected from damage.

Load cable terminations are typically located in the left front of the drive. Load cables may exit either the top or bottom of the structure. Ensure that the factory supplied phase barriers are installed before energizing the drive. Failure to do so can result in a flashover at the load connections.

Individual motor cable length should not be greater than what is recommended in Chapter 2**,** Appendix B without consulting the manufacturer. Motor cables must be kept separate from line cables and control wiring to minimize the amount of radiated noise from the motor cables. Cables must include the proper insulation for the applied voltage. Special specification cables are not required.

Control wires may enter the enclosure from either the top or the bottom. A low voltage wireway is located in the drive running from the conduit plates to the control section to facilitate top and bottom entry of control wiring. Refer to the order specific drawings for specific locations for control wireways.

All cable/wire entry openings must be sealed to reduce the risk of entry by rodents and to allow for proper airflow and cooling of components.

The SC9000 EP is provided with a ground bus that runs the full length of the drive. If the drive consists of multiple shipping sections, the ground bus must be connected across all shipping splits using the flexible shunts and hardware supplied with the drive. These will be installed on the ground bus and secured inside the drive shipping section.

Always ground the drive to prevent electrical shock and reduce electrical noise. The user is responsible for meeting all regulatory requirements with respect to grounding of the drive. Failure to observe this precaution could result in bodily injury or death.

Power factor correction capacitors or surge capacitors must not be connected to the drive output.

Chapter 5: Programming and Configuration

Medium Voltage Drives Application

Introduction

The Medium Voltage Drives Application is easy and flexible to use due to its versatile fieldbus features.

Motor Protection Functions in the Medium Voltage Drive

The Medium Voltage Drives Application provides the following protection functions:

- External fault protection
- Input phase supervision
- Undervoltage protection
- Output phase supervision
- Earth fault protection
- Motor thermal protection
- Thermistor fault protection
- Fieldbus fault protection
- Slot fault protection

Keypad Operation

Figure 18. Keypad and Display

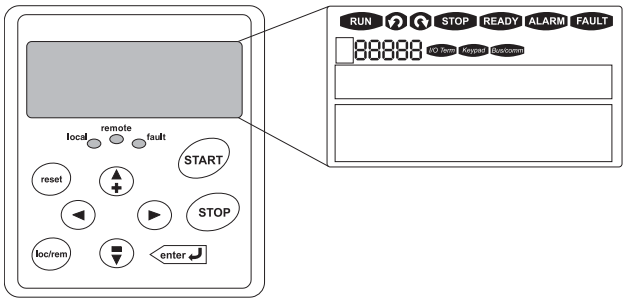


Table 7. LCD Status Indicators

Indicator	Description
RUN	**Run** Indicates that the SC9000 EP is running and controlling the load. Blinks when a stop command has been given but the SC9000 EP is still ramping down.
	Counterclockwise Operation The output phase rotation is BAC, corresponding to counterclockwise rotation of most motors.
	Clockwise Operation The output phase rotation is ABC, corresponding to clockwise rotation of most motors.
STOP	**Stop** Indicates that the SC9000 EP is stopped and not controlling the load.
READY	**Ready** Indicates that the SC9000 EP is ready to be started.
ALARM	**Alarm** Indicates that there is one or more active drive alarm(s).
FAULT	**Fault** Indicates that there is one or more active drive fault(s).
I/O Term	**I/O Terminal** Indicates that the I/O terminals have been chosen for control.
Keypad	**Keypad** Indicates that the keypad has been chosen for control.
Bus/comm	**Bus/Communications** Indicates that the communications bus control has been chosen for control.

Table 8. LED Status Indicators

Indicator	Description
Local	**Local—Steady Illumination** Indicates that the SC9000 EP is ready to be started and operated from the Local mode. **Local—Flashing** Indicates that the SC9000 EP is ready for operating command to select Local or Remote operation.
Remote	**Remote** Indicates that the SC9000 EP is operating and controlling the load remotely.
Fault	**Fault** Indicates that there is one or more active drive fault(s).

Table 9. Navigation Buttons

Button	Description
START	**Start** This button operates as the START button for normal operation when the "Keypad" is selected as the active control.
enter	**Enter** This button is used in the parameter edit mode to save the parameter setting and move to the next parameter … To reset the Fault History if pressed while in the "Fault History" menu. To confirm the acceptance of a change. To change a virtual button status while in the "Button" menu. To confirm the start-up list at the end of the Start-Up Wizard. When the "Operate" menu is active, to exit the "Operate" submenu.
STOP	**Stop** This button has two integrated operations. The button operates as STOP button during normal operation … Motor STOP from the keypad, which is always active unless disabled by the "StopButtonActive" parameter. Used to reset the active faults.
reset	**Reset** Resets the active faults.
loc/rem	**Local / Remote** Switches between LOCAL and REMOTE control for start, speed reference and reverse functions. The control locations corresponding to local and remote can be selected within an application.
◄	**Left Arrow** Navigation button, movement to left. In parameter edit mode, exits mode, backs up one step. Cancels edited parameter (exit from a parameter edit mode). When in "Operate" menu will move backward through menu. At end of "Start-Up Wizard", repeats the "Start-Up Wizard" setup menu.
►	**Right Arrow** Navigation button, movement to right. Enter parameter group mode. Enter parameter mode from group mode. When in "Operate" menu will move forward through menu.
▲ + / ▼ =	**Up and Down Arrows** Move either up or down a menu list to select the desired menu item. Editing a parameter/password, while the active digit/character is scrolled. Increase/decrease the reference value of the selected parameter. In the "Operate" menu, will cause the display of the current reference source and value and allow its change if the keypad is the active reference source. Used to set the password (if defined) when leaving the "Operate" menu. Scroll through the "Active Faults" menu when the SC9000 EP is stopped.

Menu Navigation

Navigation Tips

- To navigate within one level of a menu, use the up and down arrows
- To move deeper into the menu structure and back out, use the right and left arrows
- To edit a parameter, navigate to show that parameter's value, and press the right arrow button to enter the edit mode. In edit mode, the parameter value will flash
- When in edit mode, the parameter value can be changed by pressing the up or down arrow keys
- When in edit mode, pressing the right arrow a second time will allow you to edit the parameter value digit by digit
- To confirm the parameter change, you must press the ENTER button. *The value will not change unless the ENTER button is pushed*

Some parameters can not be changed while the SC9000 EP is running. The screen will display LOCKED if you attempt to edit these parameters while the drive is running. Stop the drive to edit these parameters. See the appropriate application manual for identification of these parameters specific to your chosen application.

Note: The following menus represent those in version 4.12 of the firmware. For information on menus for prior or subsequent versions, contact the factory.

SC9000 EP V4.12—Configuration Menus

Compatibility

SC9000 EP application version 4.12 is compatible with all drives in the field, and all current production drives. This includes SPX processor types 661, and 761. It also supports modulator types MIC, SIC, MITG, and SITG. MIC and SIC boards are identified by the presence of a seven segment display, MITG and SITG boards have a color liquid crystal display. There are some specific hardware/firmware requirements listed below:

- Type 661 processor modules must be loaded with firmware 4.61, present in firmware file NXP0000V178.VCN
- Type 761 processor modules must be loaded with firmware 4.62, present in firmware file NXP0000V179.VCN
- Proper operation of the MITG/SITG requires a 761 processor

Mappable I/O

Prior to the release of version 2.36, all of the I/O functions mapped to the remote I/O subsystem (Turck) were hard mapped in the software. This resulted in multiple software versions to accommodate the various I/O arrangements used in different frame sizes. This resulted in wasted rack space and higher cost.

Version 4.12 provides for the mapping of any I/O function (input, output, or analog input) to any module location. This feature is called mappable I/O, and is described in detail later in this document. Mappable I/O provides the flexibility needed to update any existing application already in the field. Module configuration is viewable and settable from the keypad or NCDrive. There is also a parameter in the remote I/O menu group that rapidly roughs-in configurations for common function groups.

Starting with application version 4.12c, support for two Turck bases has been added. This helps reduce wiring in drives that have dual inverters. The I/O functions required for the second inverter such as RTD's and blower flow sensors (optional) can be mapped to the second Turck base. The application automatically enables communications to the second base as soon as any function is mapped to it.

Quick Start

Choose a mode of operation:

Parameter P1.6.1 Motor Control Mode

0 = Frequency Control
1 = Open Loop Speed
2 = Open Loop Torque
3 = Closed Loop Speed
4 = Closed Loop Torque

Frequency Control

Easy to setup, does not require motor ID run, speed control least accurate, slip is not controlled, in some cases greater slip is an advantage on regenerative loads; it helps the drive avoid over-charging the bus on deceleration. Torque capability is low, less than 150%. This mode is best for pumps and fans or any non-speed critical application requiring less than 150% torque, and is the recommended starting point for most applications.

Open Loop Speed/Torque

Setup slightly more complicated, requires a motor ID run or manual entry of magnetization current. Slip compensation possible through motor model speed estimate. Speed control more accurate than V/H mode. Torque up to 150%. This mode is good for higher torque requirements such as mixers or other loads with high static friction at start-up, and slightly more sensitive to overcharging of bus on deceleration.

Closed Loop Speed/Torque

Setup is complex. *Motor ID run and shaft encoder required*. Tuning usually required. Extremely accurate speed control, high torque to 200%. Zero speed control at full torque.

Note that two types of motor identification runs are possible:

- ID with Run
- ID without Run

The best way to perform an ID run is 'ID with Run', and requires that the motor shaft be disconnected from the load. If this is not possible, an "ID without Run' may be substituted, but is not as accurate. See parameter ID PN.N.N.N for details.

Basic Setup

1. Map the remote I/O—always done at factory, but sometimes requires changes in field.
2. On systems using ITG control cards, set the CAN baud rate (P1.16.2) to 500K. Note that this is the baud rate of the OPTD2 board in slot E. Do not use the expander boards menu to set this parameter.
3. **Reboot the entire control rack.** This step only needs to be performed one time. Ensure that the SPX controller does not return a 'CAN Master' or 'CAN Slave' fault on power up. If these faults occur, repeat step 2 or check CAN wiring between SPX and modulator boards. The unpowered line impedance from CAN HI to CAN LO must be 60 to 120 ohms.
4. Verify a Green status LED on the Turck communication adapter (Bus). The LED should turn green approximately 12 seconds after power-up. If the LED refuses to turn green, check the parameters of the OPTD2 or OPTD6 in slot B. The CAN mode parameter should be set to 'CAN OPEN', and the BAUD rate set to 125K Baud. If the parameters are OK, check the wiring; the unpowered line impedance from CAN HI to CAN LO must be 60 to 120 ohms.
5. The system will NOT function properly if this LED is ORANGE.
6. If the I/O system is properly configured, all faults on the SPX and controller boards should clear when the reset button on the keypad is pressed. ITG controller cards should indicate 'Stopped'. MIC/SIC controller cards may display non-flashing fault codes, which should clear when the RESET and STOP buttons are simultaneously pressed for about 2 seconds.
7. Configure Basic Parameters. Use data found on motor name plate.

Parameter Menus

G1.1 Basic Parameters

P1.1.1 Nominal Line Voltage

Selects the nominal line voltage for input to the drive.

1 = 4160
2 = 3300
3 = 2400

P1.1.2 Minimum Frequency

Sets the minimum frequency the drive will run at when given a run command. The drive will ramp to this frequency at the ramp rate given from P1.1.4 'Acceleration Time' on receipt of a run command and not go below that frequency until the run command is released.

P1.1.3 Maximum Frequency

Sets the minimum frequency the drive will run at when given a run command under normal operating conditions (regulator or limits are not active).

P1.1.4 Acceleration Time

Sets the time in seconds for the drive to ramp from 0 Hz to maximum frequency.

P1.1.5 Deceleration Time

Set the time in seconds for the drive to ramp from maximum frequency to 0 Hz.

P1.1.6 Current Limit

Sets the user configurable current limit. The drive will alter certain behaviors such as acceleration time based on this parameter. For example, if the current limit is reached while accelerating, the motor regulator will inhibit the ramp rate to keep the current below the limit entered for this parameter.

P1.1.7 Motor Nominal Voltage

Set the motor nominal voltage at rated speed.

P1.1.8 Motor Nominal Frequency

Sets the motor nominal frequency at rated speed.

P1.1.9 Motor Name Plate RPM

Sets the motor nominal speed at rated speed.

P1.1.10 Motor Nominal Current

Rated full load motor current from nameplate.

P1.1.11 Motor Cosine Phi

Rated power factor of the motor from nameplate.

P1.1.12 Local Control Place

Sets the control place used when drive is in local mode.

P1.1.13 Remote Control Place

Sets the control place used when drive is in remote mode.

P1.1.14 Local Reference

Sets the source of the speed reference when the drive is in local mode.

P1.1.15 Remote Reference

Sets the source of the speed reference when the drive is in remote mode.

P1.1.16 Preset Speed1

Set point for speed used when the PresetSpeed1 input is made active.

P1.1.17 Preset Speed2

Set point for speed used when the PresetSpeed2 input is made active.

P1.1.18 Main Contactor Control Mode

0 = Normal

The main contactor will open immediately on a stop condition.

1 = Timed Released

The main contactor will remain closed for the number of seconds specified 'Main Contactor Holding Time' (parameter P1.1.19) on a stop condition. Note: The main contactor will open immediately on a fault condition.

P1.1.19 Main Contactor Hold Time

Specifies the number of seconds the main contactor will remain closed when the main contactor mode is set to 'Timed Release'.

P1.1.20 Passcode

Sets 5 digit passcode for accessing 'Medium Voltage' parameter group. Passcode is '11111'.

G1.2 Input Signals

P1.2.1 Start/Stop Logic

Selects the logic used by DIN1 and DIN2 used to start and stop the drive.

0 = Forward – Reverse
1 = Start – Reverse
2 = Start – Enable
3 = StartP – Stop Pulse
4 = ForwR – RevR
5 = StartR – Rev
6 = StartR = Enable

0 = DIN1 is forward RUN, DIN2 is reverse Run
1 = DIN1 is RUN, DIN2 is direction (reverse when active)
2 = DIN1 is RUN, DIN2 is enable (enable when active)
3 = DIN1 is Latched RUN, DIN2 is normally closed STOP (emulates three-wire control).
4 = DIN1 is Forward RUN, DIN2 is Reverse Run
5 = DIN1 is Forward RUN, DIN2 is Reverse Run
6 = DIN1 is Forward RUN, DIN2 is Reverse Run

P1.2.2 DIN3 Function

Sets the function mapped to digital input 3 on the OPTA9 card in slot A.

Available functions:

0 = None
1 = External Fault Close
2 = External Fault Open
3 = Run Enable
4 = Acceleration/Deceleration Time
5 = Force Local
6 = Force Remote
7 = Reverse
8 = Force Drive
9 = Force Bypass
10 = Overload Relay
11 = Motor Pot Up
12 = Motor Pot Down
13 = PID Control Active
14 = Fault Reset
15 = Preset Speed1
16 = Sync Field OK
17 = Sync Up
18 = Sync Down
19 =Transfer GO

P1.2.3 DIN4 Function

Sets the function mapped to digital input 4 on the OPTA9 card in slot A. Mapping is the same as DIN3.

P1.2.4 DIN5 Function

Sets the function mapped to digital input 5 on the OPTA9 card in slot A. Mapping is the same as DIN3.

P1.2.5 DIN6 Function

Sets the function mapped to digital input 6 on the OPTA9 card in slot A. Mapping is the same as DIN3.

P1.2.6 Current Reference Offset

P1.2.7 Reference Scale Minimum Value

P1.2.8 Reference Scale Minimum Value

P1.2.9 Reference Invert

P1.2.10 Reference Filter Time

P1.2.11 AI1 Signal Select

P1.2.12 AI2 Signal Select

P1.2.13 AI3 Signal Select

P1.2.14 Motor Potentiometer Reference Memory

G1.3 Output Signals

G1.4 Drive Control

P1.4.1 Ramp 1 Shape

P1.4.2 Ramp 2 Shape

P1.4.3 Acceleration Time 2

P1.4.4 Deceleration Time 2

P1.4.5 Start Function

P1.4.6 Stop Function

P1.4.7 Flux Brake

P1.4.8 Flux Brake Current

P1.4.9 Fly Start Options

G1.5 Prohibit Frequency

G1.6 Motor Control

P1.6.1 Motor Control Mode

0 = Frequency Control
1 = Open Loop Speed
2 = Open Loop Torque
3 = Closed Loop Speed
4 = Closed Loop Torque

P1.6.2 U/f Optimization

Auto torque boost in case of open loop control operation can be enabled with parameter.

0 = None
1 = Auto torque boost (Auto torque boost is enabled).

It is recommended to enable auto torque boost only if successful ID run is performed during the commissioning.

P1.6.3 U/f Ratio Select

Select the U/f ratio in case of open loop control operation.

0 = Linear
1 = Squared
2 = Programmable

Parameters P2.6.5.2 U/f zero point voltage, P2.6.5.3 U/f mid point voltage, P2.6.5.4 U/f mid point frequency are required to be adjusted in this selection. If the ID run is successfully done, those parameter are set to their optimum values.

P1.6.4 Field Weakening Point

The field weakening point is the output frequency at which the motor voltage reaches the value of P1.6.1, Voltage at FWP in percentage. This parameter is applicable during open loop control of the motor. Normally this parameter is set equal to motor nominal frequency.

P1.6.5 Voltage at Field Weakening Point

Percentage value of the motor voltage at the field weakening point defined by P2.1.9. Above the field weakening point frequency the voltage remains to the value set by this parameter. This parameter is applicable during open loop control of the motor. Normally this parameter is set to 100.00% of motor nominal voltage.

P1.6.6 U/f Midpoint Frequency

Mid point frequency reference in case of programmable U/f curve. This can be set as (P2.6.5.2 U/f zero point voltage * P2.1.3 Motor nominal frequency) /100.

P1.6.7 U/f Midpoint Voltage

Motor voltage as a percentage of motor nominal voltage at frequency reference equal to P2.6.5.4 U/f mid point frequency. This can be set as 1.41* P2.6.5.2 U/f zero point voltage.

P1.6.8 Zero Frequency Voltage

Motor voltage as a percentage of motor nominal voltage at zero frequency reference. This can be set to produce motor current equal to 80...100% of nominal magnetizing current at zero frequency reference.

P1.6.9 Over Voltage Control

Overvoltage controller can be activated with this parameter.

0 = Off
1 = On, no ramp. Overvoltage controller is P type controller.
2 = On with ramp. Overvoltage controller is PI type controller.

The drive corrects the frequency reference internally when the DC link voltage rises above the overvoltage reference level selected by parameter P2.6.6.6 Overvoltage reference selection. The correction in the frequency reference can be seen in V1.1.1 Output frequency when over voltage controller is active and the DC link voltage is above the overvoltage reference.

P1.6.10 Load Drooping

Load drooping as a percentage of nominal speed at nominal torque. Load drooping allows the static speed error as a function of a load torque. For e.g. If Load drooping is set as 10% then for 100% motor torque the drive will allow actual speed less than 10% nominal speed of the motor. It can be used to smoothen out the load torque variation or also to share the load torque between the two drive systems when the coupling between the drive systems is not rigid.

P1.6.11 Identification

This parameter defines the different modes of the automatic motor identification run. Set the parameter and give the run command within 30 seconds to activate the identification.

The parameter is reset to zero (None) after the identification is complete. In case of failure Alarm 57 ID Run Fail is generated.

0 = None
1 = Identification without motor running

The identification is performed with motor at standstill. In this mode motor stator resistance and parameters for U/F curve are identified. At the end of the identification the parameter P2.6.5.1 U/f Ratio Select is set equal to 2 (programmable). This Identification mode is used when it is not possible to decouple the motor from the gearbox and load. The identification optimizes the performance for open loop motor control mode i.e. P2.7.4 = 0/1/2.

After the successful identification B0 of variable ID Run Status is Set.

2 = Identification with motor running

The identification is performed with motor running. It is recommended to decouple the motor from the gearbox and the load. In addition to the motor parameters for open loop motor control, magnetizing current (P2.1.8) and flux linearization curve (P2.14.1 to P2.14.15) are identified.

After the successful identification B0, B2 and B3 of variable ID Run Status is Set.

3 = Encoder ID

The motor may rotate during the identification. The function is primarily used to identify the shaft zero position for PMSM motor when absolute encoder is used.

4 = Magnetization current calculation

In this identification, the magnetization current of the motor for a given motor data (P2.1.2…P2.1.6) is calculated.

Note: The motor is not subjected to any voltage or current. Giving a run command.

G1.6.13 Closed Loop

P1.6.13.1 Magnetization Current

Sets the nominal magnetizing current for the motor corresponding to 100% flux. The value of the parameter (if not known) can be found out by performing following test on the motor. Note that the motor must be decoupled from the gearbox and the load while doing the following test.

- Set all the nameplate parameters of the motor P3.1.2 to P3.1.6.
- Set P3.7.4 Motor Ctrl Mode = 0 (Open Loop Frequency control)
- Run the motor with no load on the shaft with approx. 0.66*Rated Frequency (33 Hz for 50 Hz motor)
- Wait for 10 seconds and then note the value of signal V1.1.5Motor Current
- Set this value to P2.1.8 Magnetizing Current

P1.6.13.2 Speed Control Kp

Gain for the speed controller in closed loop motor control operation. Gain value 100 means nominal torque reference is produced at the speed controller output for the frequency error of 1 Hz.

P1.6.13.3 Speed Control Ki

Integral time constant in ms for the speed controller in closed loop motor control operation.

P1.6.13.4 Reserved

P1.6.13.5 Accel Compensation

Time constant for the acceleration compensation of the fixed inertia of the drive system in closed loop motor control operation. It can be calculated as follows.

$$\text{AccelCompensationTC} = J\frac{2\pi f_{nom}}{T_{nom}} = J\frac{(2\pi f_{nom})^2}{P_{nom}}$$

Where:

J = total system inertia in kg*m^2

f_{nom} = motor nominal frequency in Hz

T_{nom} = motor nominal torque

P_{nom} = motor nominal power in kW

The final Iq reference is added with additional Iq reference V1.2.23 Acceleration compensation Out proportional to inertia torque during acceleration deceleration. Note that fixed inertia like ? (motor inertia, gear box inertia, basic roll inertia) only can be compensated with this parameter. Variable load inertia.

P1.6.13.6 Slip Adjust

This parameter can be tuned to compensate for inaccuracies in the motor nominal speed data on the motor nameplate. Also the V1.2.36 Rotor time constant estimated by the motor model can be adjusted with this parameter. The rotor time constant varies with the motor temperature. The compensation for the rotor time constant as a function of measured motor temperature using either TS1 or TS2 (PT100 temperature sensor) can be given by setting P2.13.29 Motor temperature compensation. The P2.9.17 Slip adjust is then internally modified as a function of measured motor temperature.

P1.6.13.7 Start Magnetization Current

P1.6.13.8 Start Magnetization Time

P1.6.13.9 Start Zero Speed Time

P1.6.13.10 Startup Torque

P1.6.13.11 Startup Torque REV

P1.6.13.12 Encoder1 Filter Time

P1.6.13.13 Closed Loop Over Voltage Reference

P1.6.13.14 Closed Loop Over Voltage Protection Enabled

P1.6.13.15 Closed Loop Over Voltage Droop

G1.7 Protections

G1.8 Auto Restart

P1.8.1 Wait Time

Specified the amount of time that will elapse between the fault condition clearing and the drive restarting.

P1.8.2 Trial Time

Specifies the amount of time allowed for auto-restart attempts, before the drive will declare a hard fault.

P1.8.3 Start Function

Specifies the method used to restart the drive, such as ramp, fly-start, or system defined.

P1.8.4 Undervoltage Fault Tries

Specifies the number of times to repeat the time the **Undervoltage** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.5 Overvoltage Fault Tries

Specifies the number of times to repeat the time the **Overvoltage** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.6 Overcurrent Fault Tries

Specifies the number of times to repeat the time the **Overcurrent** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.7 4ma fault Tries

Specifies the number of times to repeat the time the **4ma fault** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.8 Motor Temperature Fault Tries

Specifies the number of times to repeat the time the **Motor Temperature** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.9 External Fault Tries

Specifies the number of times to repeat the time the **External Fault** fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

P1.8.10 Underload Fault Tries

Specifies the number of times to repeat the time the **Underload** voltage fault condition is allowed and restart attempted, within the trial time window. If the condition persists longer than the trial time and fails to clear, at hard fault occurs.

G1.9 PID Control

G1.10 Torque Control

G1.11 SETTINGS

P1.11.1 COOLING

P1.11.1.1 Cabinet Temp Delta

Maximum temperature rise allowed before blowers are turned on. The rise is calculated by subtracting the ambient temperature from the highest internal temperature measured at several locations inside the drives enclosure. If the result is greater than the blower rise temperature, the blowers will run. Note: starting with version 4.12c, the blowers will also run if the DC bus is charged.

P1.11.1.2 Rated Ambient

Specifies the maximum temperature for the ambient air the drive will see at its input filters. A 'Hi Ambient' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the maximum temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.3 Transformer Core

Specifies the maximum temperature for the main transformer core. A 'XfmrOTCore' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the maximum temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.4 Transformer Coil

Specifies the maximum temperature for the main transformer coils. A fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the max temperature by the temperature warning percent (parameter P1.11.3.2).

The warnings that may occur are:

'XfmrOTF/L'Transformer Front/Left Coil Over temperature

'XfmrOTMiddle'Transformer Center Coil Over temperature

'XfmrOTR/R'Transformer Right/Rear Over temperature

P1.11.1.5 Inverter Heatsink

Sets the maximum temperature allowed for the inverter heat sink. An 'InverterOT' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the max temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.6 Bridge Rectifier

Sets the maximum temperature allowed for the bridge rectifier heat sink. A 'RectifierOT' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the maximum temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.7 Reactor/Inductor

Sets the maximum temperature allowed for the reactor/inductor. A 'ReactorOT' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the max temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.8 Discharge Resistor Warning

Sets the maximum temperature allowed for the discharge resistor heat sink. A 'ResHeatSink' fault will occur if the temperature exceeds this value. A warning will be indicated if the temperature exceeds the warning threshold. The warning threshold is calculated by multiplying the maximum temperature by the temperature warning percent (parameter P1.11.3.2).

P1.11.1.9 Blower Minimum Flow (Optional)

When the flow falls below the level set by 'BlowerMinFlow', P1.11.1.9 the drive will fault on 'BlowerLoss'. When the level falls below the level defined by 'FlowWarnPercent', P1.11.2.1, the drive will indicate a 'MainBlower' warning (but will not trip). NOTE: If the drive is equipped with redundant blowers, it will not fault. It will instead indicate a 'MainBlower' warning and attempt to rotate to redundant blower mode. If redundant blowers also fail, the drive will fault on 'BlowerLoss'. Main blower flow sensors must be mapped for main blower flow rate protection to be enabled.

P1.11.1.10 Blower Exchange Time

If the drive is equipped with redundant blowers, this parameter specifies the amount of hours the main blowers will run before rotating to redundant. The redundant blowers will then run for the same amount of time before rotating to main and the cycle will repeat.

P1.11.2 Advanced

P1.11.2.1 Flow Warning Percent (Optional)

Specifies the percentage of any airflow fault level that a warning will occur at. The number is greater than 100%, since the warning level for air flow would be higher than the fault level.

P1.11.2.2 Temperature Warning Percent

Specifies the percentage of any temperature fault level that a warning will occur. The number is less than 100%, since the warning level for temperature would be lower than the fault level.

P1.11.2.3 Flow Hysteresis (Optional)

Specifies the flow level hysteresis used with any airflow measurement. Units are liner feet per minute. This parameter prevents any blower or fan relay from chattering around the ON/OFF transition point.

P1.11.2.4 Inverter Temperature Hysteresis

Specifies the deadband for inverter over-temperature faults. This in the number of degrees C that the temperature must fall before the fault will clear.

P1.11.2.5 Transformer Core Temperature Hysteresis

Specifies the deadband for transformer core over-temperature faults. This in the number of degrees C that the temperature must fall before the fault will clear.

P1.11.2.6 Transformer Coil Temperature Hysteresis

Specifies the deadband for transformer coil over-temperature faults. This in the number of degrees C that the temperature must fall before the fault will clear.

P1.11.2.7 Fan Fault Delay

Specifies the delay in seconds before an inverter fan fault is indicated.

P1.11.2.8 Sine Filter Minimum Flow (Optional)

Specifies the minimum air flow fault level for the optional sine filter cooling fan.

P1.11.2.9 Start De-bounce Time

This is a programmable debounce time used to condition the DIN1 start signal from noisy outputs from a PLC or DCS system (rising edge delay).

P1.11.2.10 Stop De-bounce Time

This is a programmable de-bounce time used to condition the DIN1 start signal from noisy outputs from a PLC or DCS system (falling edge delay).

G1.12 Medium Voltage

Parameters in this group are used in open or closed loop vector mode and should not be adjusted when the drive is in Voltz/Hertz mode. Some are used for advanced options and if set incorrectly, could damage the drive.

P1.12.1 Medium Voltage Index

Sets internal voltage scaling for modulator boards based on utility grid. This parameter is set automatically when the nominal line voltage is set (P1.1.1).

P1.12.2 Torque Stabilator Gain

Gain for the torque stabilator in open loop motor control operation. The range for the gain value is 0 to 1000.

P1.12.3 Torque Stabilator Damping

Damping rate for the torque stabilator in open loop motor control operation. The range is 0 to 1000.

P1.12.4 Torque Stabilator Gain Field Weakening Point

Gain of the torque stabilator at field weakening point in open loop motor control operation. The range is 0 to 1000.

P1.12.5 Voltage Stabilator Damping

Damping rate for the voltage stabilator. The range is 0 to 1000.

P1.12.6 Voltage Stabilator Gain

Gain for the voltage stabilator. The range is 0 to 1000. The function of the voltage stabilator is to stabilize the variations in the DC link voltage caused due to load or incoming supply variations.

P1.12.7 OverVolta_Kp_Add

Additional gain of the P-term of the PI type overvoltage controller at field weakening point.

P1.12.8 OverVolta_Kp

Gain of the P-term of the PI type overvoltage controller. The range is 0 to 32767.

P1.12.9 OverVolta_Ki

Gain for the I-term of the PI type overvoltage controller.

P1.12.10 UnderVoltage_Kp

Gain for the P-term of the PI type under voltage controller.

P1.12.11 UnderVoltage_Ki

Gain for the I-term of the PI type under voltage controller.

P1.12.12 Restart Delay

Delay time within which the drive cannot be restarted after the coast stop. The time can be set up to 60.000 seconds.

P1.12.13 Short Restart Delay

TBD

P1.12.14 Ids Stabilator Gain Ref

TBD

P1.12.15 Ids Filter Coefficient

TBD

P1.12.16 FlyStart DC Magnetization Current

TBD

P1.12.17 Flux Circle Stabilization Gain

Gain of the flux stabilator in open loop motor control operation. The range is 0 to 32000.

P1.12.18 Over Voltage Kd

TBD

P1.12.19 Motor Over Current Kp

Gain for the P-term of the PI type overcurrent controller.

P1.12.20 Motor Over Current Ki

Gain for the I-term of the PI type overcurrent controller.

P1.12.21 Current Control Kp

Gain for the current controller in closed loop motor control operation. Range 1 to 10000. Note that in normal cases the default value is sufficient and there is no need to change this parameter.

P1.12.22 Current Control Ti

Integral time constant for the current controller in closed loop motor control operations. Range 0 to 100.0 milliseconds. Note that in normal cases the default value is sufficient and there is no need to change this parameter.

P1.12.23 Over Modulation Limit

TBD

P1.12.24 Dead Time Compensation

TBD

P1.12.25 Dead Time Con Current Limit

TBD

P1.12.26 Voltage Scale

Sets internal voltage scaling for modulator boards based on utility grid. This parameter is set automatically when the nominal line voltage is set (P1.1.1).

P1.12.27 Number Of Slaves

Legacy parameter. No longer used.

P1.12.28 Generator Over Current Kp

Gain for the generating current controller in closed loop motor control operation. Range 1 to 10000. Please note that in normal cases the default value is sufficient and there is no need to change this parameter.

P1.12.29 Generator Over Current Ki

Integral time constant for the generating current controller in closed loop motor control operations.

Range 0 to 100.0 milliseconds. Note that in normal cases the default value is sufficient and there is no need to change this parameter.

P1.12.30 Advanced Options

Reserved

P1.12.31 Main Hour

Hour counter for main blower run time. Retentive.

P1.12.32 Redundant Hour

Hour counter for redundant blower run time. Retentive.

G1.12.33 Test Cycle

P1.12.33.1 Test Cycle Active

Activates the test cycle feature. This feature is for manufacturing test. The test cycle uses the drive's internal current regulator to cycle between two test currents. A proper load needs to be applied so that the limit current can be reached (the current limit cannot force a higher current than is required by the load). The test current levels must be properly set or a fault may occur (cannot be set higher than thermal trip for trip time curve when thermal overload is set, for example). The drive will cycle at time intervals and currents specified below, indefinitely. Failure to turn the test cycle off may result in improper operation of the drive in the field. Note: the test mode reprograms the current limit parameter on the fly, so when test mode is active, the current limit parameter entered in the basic parameter menu will not function.

P1.12.33.2 TestTime1

Test time interval used for test current 1.

P1.12.33.3 TestTime2

Test time interval used for test current 2.

P1.12.33.4 TestCurrent1

Current level in amperes, used in time interval specified by TestTime1.

P1.12.33.5 TestCurrent2

Current level in amperes, used in time interval specified by TestTime2.

P1.12.33.6 FastBlowerSchedule

Forces blower rotation to uses seconds instead of minutes, used mainly by plant personal to check blower rotation.

P1.12.333.7 MainBlowerMode

Forces main blower behavior.

0 = AUTO. Blowers follow internal program logic and set points.
1 = FORCE ON. Blowers are forced ON at all times.
2 = FORCE OFF. Blowers are forced OFF at all times.

P1.12.33.8 RedunBlowermode

Forces redundant blower behavior.

0 = AUTO. Blowers follow internal program logic and set points.
1 = FORCE ON. Blowers are forced ON at all times.
2 = FORCE OFF. Blowers are forced OFF at all times.

P1.12.33.9 MainFanMode

Forces main inverter fan behavior.

0 = AUTO. Inverter fans follow internal program logic and set points.
1 = FORCE ON. Inverter fans are forced ON at all times.
2 = FORCE OFF. Inverter fans are forced OFF at all times.

P1.12.33.10 RedunFanMode

Forces redundant inverter fan behavior.

0 = AUTO. Inverter fans follow internal program logic and set points.
1 = FORCE ON. Inverter fans are forced ON at all times.
2 = FORCE OFF. Inverter fans are forced OFF at all times.

G1.12.34 Discharge Resistor

P1.12.34.1 Discharge Resistor Thermal Impedance

Thermal impedance of the DC bus discharge resistor. Used in the internal cooling model of the drive. Set during manufacture of drive and should not be changed. This is the thermal impedance from the resistor hot spot to Heatsink in degrees C /watt.

P1.11.34.2 Discharge Resistor Value

Specifies the value in Ohms of the DC bus discharge resistor.

G1.13 Fieldbus

P1.13.1 Fieldbus Data In 1 Select

Maps a parameter ID to the 'FBProcessDataIn1' variable (parameter ID. This parameter allows a value to be passed over a fieldbus interface to the application program. Use of this parameter requires that the variable being set is changeable while the drive is in run mode. Generally if the parameter can be set on the keypad when running, the parameter will work in this function.

P1.13.2 Fieldbus Data In 2 Select

Maps a parameter ID to the 'FBProcessDataIn2' variable. This parameter allows a value to be passed over a fieldbus interface to the application program. Use of this parameter requires that the variable being set is changeable while the drive is in run mode. Generally if the parameter can be set on the keypad when running, the parameter will work in this function.

P1.13.3 Fieldbus Data Out 8 Select

Maps a parameter ID to the 'FBProcessDataOUT8' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.4 Fieldbus Data Out 7 Select

Maps a parameter ID to the 'FBProcessDataOUT7' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.5 Fieldbus Data Out 6 Select

Maps a parameter ID to the 'FBProcessDataOUT6' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.6 Fieldbus Data Out 5 Select

Maps a parameter ID to the 'FBProcessDataOUT5' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.7 Fieldbus Data Out 4 Select

Maps a parameter ID to the 'FBProcessDataOUT4' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.8 Fieldbus Data Out 3 Select

Maps a parameter ID to the 'FBProcessDataOUT3' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.9 Fieldbus Data Out 2 Select

Maps a parameter ID to the 'FBProcessDataOUT2' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.10 Fieldbus Data Out 1 Select

Maps a parameter ID to the 'FBProcessDataOUT1' variable. This parameter allows a value to be read from the SC9000 EP over any fieldbus.

P1.13.11 Fieldbus Minimum Scale

Sets the minimum scaling factor for fieldbus or analog inputs. If this parameter is set to a value other than 0, the drive will align the minimum frequency to this value. Example: Assuming the minimum frequency has been set to 45 Hz; if **Fieldbus Minimum Scale** is set to 45, then the drive will use 45 Hz as the reference value when 4 mA is present on an analog input. If it is set to zero, the frequency reference will not advance until the analog input goes over 16 mA, the point corresponding to 45 Hz.

P1.13.12 Fieldbus Maximum Scale

Sets the maximum scaling factor for fieldbus or analog inputs. If this parameter is set to a value other than 60, the drive will align the maximum frequency to this value. Example: Assuming the maximum frequency has been set to 45 Hz; if **Fieldbus Maximum Scale** is set to 45, then the drive will use 45 Hz as the reference value when 20 mA is present on an analog input. If it is set to 60, the frequency reference will not advance once the analog input goes over 16 mA, the point corresponding to 45 Hz.

G1.14 SINEFILTER

This parameter group configures a boost voltage transfer function to compensate for the voltage drop present when a sine-wave filter is used at the output of the drive.

P1.14.1 Voltage Boost Function

0 = Disable
1 = Enable

P1.14.2 BoostPwrMin

Minimum current level used for bottom end of transfer function (independent variable).

P1.14.3 BoostPwrMax

Maximum current level used for top end of transfer function (independent variable).

P1.14.4 BoostVoltsLow

Voltage boost percentage used for bottom end of transfer function (dependent variable).

P1.14.5 BoostVoltsHigh

Voltage boost percentage used for top end of transfer function (dependent variable).

P1.14.6 ModIndexLimit

Maximum modulation index allowed when voltage boosting (percentage).

G1.15 Synchronous Field Control

This parameter group configures the control algorithm and interlocking when using a low voltage drive as an exciter for synchronous field applications.

P1.15.1 SyncFieldMode

Controls the operation of Synchronous field control mode.

0 = Disable
1 = Enable

P1.15.2 Exciter Type

Sets the mode of operation for control of the exciter. Transfer function is the preferred mode for startup and roughing in a system. A typical mode of operation is to control the field current as a function of stator frequency. PID mode is most accurate but requires a reliable source of feedback for power factor.

0 = None
1 = PID
2 = Stepped
3 = Transfer Function
4= Test Sweep

P1.15.3 Reference Source

Sets the origin of the reference source.

0 = Off
1 = Analog Input 1
2 = Analog Input 2
3 = Analog Input 3
4 = Motor Current
5 = Cosine Phi (Power Factor)
6 = Frequency Output
7 = Keypad
8 = Testmode
9 = Motor Simulation

P1.15.4 Reference Filter

Filter time in milliseconds used with reference source.

P1.15.5 Reference Input Minimum

Minimum value used for bottom end of reference input transfer function (independent variable).

P1.15.6 Reference Input Maximum

Maximum value used for top end of reference input transfer function (independent variable).

P1.15.7 Reference Output Minimum

Minimum value used for bottom end of reference input transfer function (dependent variable).

P1.15.8 Reference Output Maximum

Maximum value used for bottom end of reference input transfer function (dependent variable).

P1.15.9 Exciter Out Minimum

P1.15.10 Exciter Out Maximum

G1.15.11 PID for Field

P1.15.11.1 Actual Source

Selects the source of the signal used for feedback in the PID controller.

0 = Off
1 = Analog Input 1
2 = Analog Input 2
3 = Analog Input 3
4 = Motor Current
5 = Cosine Phi (Power Factor)
6 = Frequency Output
7 = Keypad
8 = Testmode
9 = Motor Simulation

P1.15.11.2 Actual Filter Time

Time constant applied to actual source (milliseconds).

P1.15.11.3 Polarity

Polarity applied to actual source. This parameter is used to set positive or negative feedback to the PID controller.

0 = Fixed to 1 (Non-invert)
1 = Fixed to -1 (invert)
2 = Reserved
3 = Reserved

P1.15.11.4 Scale

Sets the scale factor applied to the gain parameters of the PID controller.

P1.15.11.5 Proportional Gain K

Sets the proportional gain of the PID field controller.

P1.15.11.6 Integral Gain I

Sets the integral gain of the PID field controller.

G1.16 REMOTE I/O

P1.16.1 FrameStyle

This is a macro that maps a block of common I/O to the Turck I/O rack. The most basic technique for mapping I/O is to select an individual function for each I/O module that matches the drives' wiring. The frame style parameter allows entire blocks of I/O for common configurations to be selected. This helps expedite the mapping of I/O. The frame style parameter may be used multiple times to arrive at a final configuration, and individual items may be changed after the frame style parameter has been used. There is also a selection to clear the configuration and start over.

0 = Clear
1 = Basic Frame A Basic I/O
2 = Basic Frame B Basic I/O
3 = Basic Frame C Basic I/O
4 = Frame D 2400V
5 = Frame D 4160V
6 = Frame E 4160V
7 = Sync Transfer Function Adder
8 = Sync Field Control Function Adder

P1.16.2 CAN to Modulator (MIC/SIC/ITG) Baud Rate

The SPX controller to modulator CAN interface requires 500K baud when an ITG style controller card is used. The default baud rate of a new SPX controller is 50K Baud. On first power-up of an ITG based control rack, this parameter should be set to 500K. The parameter will not be set until the next reboot of the control rack. This operation only needs to be repeated one time after the parameter has changed.

G1.16.3 Digital Output Group

Selects the function used for an output module (Example: Out1AFunc selects the function of output module 1, output A). Available Output Functions:

0 = Force Off
1 = Force On
2 = Main Blower
3 = Redundant Blower
4 = Main Fan
5 = Redundant Fan
6 = Drive Run (Run output command for modulator boards)
7 = Main Contactor Status
8 = Fault Indicator
9 = Flashing Run Indicator
10 = Reset Out
11 = Output Contactor Unlatch
12 = Output Contactor Latch
13 = Output Contactor Maintained
14 = Ready
15 = None Flashing Run Indicator
16 = Fault
17 = Over Temperature Warning
18 = External Fault
19 = Reference Fault
20 = Warning
21 = Reverse
22 = At Speed
23 = Thermal Fault
24 = Exciter Run Out (For synchronous motor exciter control)
25 = Isolation Contactor Unlatch
26 = Isolation Contactor Latch
27 = Bypass Contactor Unlatch
28 = Bypass Contactor Latch
29 = Bypass Contactor Hold
30 = Sync Transfer Acknowledge (Indicates that drive is synchronized to the line via OPTD7)
31 = Sync Transfer Complete
32 = Preset Speed
33 = Remote Indication
34 = Local Indication
35 = Current Limiter Active
36 = 100ms Tick
37 = 500ms Tick

Description of Output Functions

0 = Off

Forces output to an off state at all times.

1 = On

Forces output to an on state at all times.

2 = Main Blower

Active when drive requests run of main blowers. Main blowers are usually located at the front top of drive.

3 = Redundant Blower

Active when drive requests run of redundant blowers. Redundant blowers are usually located at the very top of drive, and are optional equipment.

4 = Main Fan

Active when drive requests run of main fans. Main fans are usually located at the top of the inverter adjacent to the inverter heat exchanger.

5 = Redundant Fan

Active when drive requests run of redundant fans. Redundant fans are usually located at the top of the inverter adjacent to the inverter heat exchanger.

6 = Drive Run

Active when drive is in run mode. This output is maintained on any time the inverter is providing output frequency.

7 = Main Contactor Aux Status

Active when main contactor is closed, this output is on.

8 = Fault Indicator

Active when the drive is faulted. This output will alternate from on to off if a warning condition occurs. If the warning condition progresses to a fault, the output will transition to solid on.

9 = Run Indicator Flash

Output used to indicate RUN and DC bus status. This Output will go solid on if the drive is running (inverter is firing). The output will also flash to indicate that the DC bus is charged, and will do so even if the drive is not running (inverter is firing).

10 = Reset Out

Output goes active during a reset operation.

11 = Output Contactor Open

Active when drive requests that the output contactor open. This output is normally used to control the unlatch coil of the medium voltage output contactor. This is a pulsed output signal controlled by drive logic and has one second duration.

12 = Output Contactor Close

Output turns on when drive requests that output contactor close. This output is normally used to control the latch coil of the medium voltage output contactor. This is a pulsed output signal controlled by drive logic and has one second duration.

13 = Start

Output turns on during the start sequence of the drive. This output also covers the time during charging of the DC bus (i.e. the output transitions on at the run request and before the inverter starts to fire). The output remains on during the entire duration of run.

14 = MVD_Ready

Output turns on when all prerequisite inputs for start are satisfied (or are un-mapped). The following input states are required:

Run Enable = ON
Mapped to DIN3 through DIN6, or Unmapped.

Isolation Switch = OFF
Mapped on remote input 1a through 7b, or Unmapped.

Phase Monitor = OFF
Mapped on remote input 1a through 7b, or Unmapped.

Bypass Monitor = OFF
Mapped on remote input 1a through7b, or Unmapped.

The drive will not start if any of these conditions are not met, and a message will be displayed on the keypad indicating what condition(s) are not met when a start is attempted.

15 = Run Indicator no Flash

Output behave like option 9 (Run Indicator Flash), but does not flash when bus is charged. This output is useful to provide feedback to a PLC, where option 9 is more useful for driving a pilot lamp.

16 = Fault

Output turns on during an active fault condition, but does not blink during a warning (remains solid during a warning for use with a PLC).

17 = Over Temperature Warning

Output turns on when the hottest internally measured temperature in higher than the warning level found in the settings group.

18 = External Fault

Output turns on during an external fault condition occurs.

19 = Reference Fault

Output turns on when reference for speed is lost (4–20 mA level less than 4 mA, or field bus is lost).

20 = Warning

Output turns on during any warning condition internal to drive.

21 = Reverse

Output turns on when drive is in reverse run mode.

22 = At Speed

Output turns on when drive output frequency is within +/- 1% of frequency reference.

23 = Thermal Overload Fault

Output turns on when a thermal overload trip occurs (I^2T limit exceeded).

24 = Exciter Run

Output used as a run command for external excitation system. Active only when I synchronous field motor mode (P1.15.1) is set to 'enable'.

25 = Isolation Switch Unlatch—Reserved

26 = Isolation Switch Latch—Reserved

27 = Bypass Contactor Unlatch

Output turns on when drive requests that bypass contactor opens. This output is normally used to control the unlatch coil of the medium voltage bypass contactor. This is a pulsed output signal controlled by drive logic and has one second duration.

28 = Bypass Contactor Latch

Output turns on when drive requests that bypass contactor close. This output is normally used to control the latch coil of the medium voltage bypass contactor. This is a pulsed output signal controlled by drive logic and has one second duration.

29 = Bypass Contactor Hold

Output turns on when drive requests that bypass contactor closes, and remains on for the entire duration of the hold time. This output is normally used to control the holding coil of the medium voltage bypass contactor. This is a maintained output signal controlled by drive logic.

30 = 100 Millisecond Tick

Output is forced to cycle with a 100 ms period. Useful for debugging.

31 = 500 Millisecond Tick

Output is forced to cycle with a 500 ms period. Useful for debugging.

G1.16.4 Digital Input Group

Selects the function used for an input module (Example: In1AFunc selects the function of input module 1, input A). Available Input Functions:

0 = None
1 = Phase Monitor
2 = DI2
3 = Main Isolation Switch
4 = Aux. Estop
5 = Remote Estop
6 = Main Contactor Status
7 = Bypass Contactor Status
8 = Output Contactor Status
9 = Sine Filter Cap Over Pressure
10 = Sine Filter Inductor Over Temperature
11 = Inverter 1 Phase U Balancing Reactor Over Temperature
12 = Inverter 1 Phase V Balancing Reactor Over Temperature
13 = Inverter 1 Phase W Balancing Reactor Over Temperature
14 = Inverter 2 Phase U Balancing Reactor Over Temperature
15 = Inverter 2 Phase V Balancing Reactor Over Temperature
16 = Inverter 2 Phase W Balancing Reactor Over Temperature
17 = Sync Down
18 = Sync Up
19 = Transfer Go
20 = Motor Select 1
21 = Filter Air Temperature
22 = Main Blower Auxiliary 1
23 = Main Blower Auxiliary 2
24 = Redundant Blower Auxiliary

Description of Input Functions

0 = None

1 = Phase Monitor Relay

The input monitors the state of the phase monitor relay. The input in normally off when the phase sequence and voltages are correct. A high state on this input will cause a warning or fault to occur.

2 = DI2 (Reserved)

3 = Isolation Switch

The input monitors the state of the isolation switch. A high state in this input indicates the isolation switch is open. The input must be low for the drive to run. If this function is not mapped, isolation switch monitoring will be disabled, and the drive will run regardless of the state of the isolation switch.

4 = Auxiliary Emergency Stop

Monitors the auxiliary emergency stop circuit. A low state on an input mapped to this function will cause the drive to trip with an 'auxiliary emergency stop' message displayed on the keypad.

5 = Remote Emergency Stop

Monitors the remote emergency stop circuit. A low state on an input mapped to this function will cause the drive to trip with a 'remote emergency stop' message displayed on the keypad.

6 = Main Contactor Sense

Monitors the state of the main contactor. A high state in this input indicates the main contactor is closed. The input must be high for the drive to run. This function must be mapped for the drive to run.

7 = Bypass Contactor Sense

Monitors the state of the bypass contactor. A high state in this input indicates the bypass contactor is closed. The input must be low for the drive to run. If this function is not mapped, bypass contactor monitoring will be disabled, and the drive will run regardless of the state of the bypass contactor.

8 = Output Contactor Sense

Monitors the state of the output contactor. A high state in this input indicates the output switch is open. The input must be low for the drive to run. If this function is not mapped, output contactor monitoring will be disabled, and the drive will run regardless of the state of the output contactor.

Note: Items 9 through 16 require single temperature normally closed Clix-On style devices for proper operation.

9 = Sine Filter Capacitor Over-Pressure

Monitors the state of the overpressure switch used on the sine filter capacitors. When mapped to an input, an open circuit will cause the drive to trip with a capacitor over-pressure fault.

10 = Sine Filter Inductor Over-Temperature

Monitors the state of the over-temperature switch used on the sine filter inductor. When mapped to an input, an open circuit will cause the drive to trip with an inductor over temperature fault.

11 = Inductor #1 Phase U Over-Temperature Switch

Monitors three phase line reactor #1, phase U temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

12 = Inductor #1 Phase V Over-temperature Switch

The input monitors three phase line reactor #1, phase V temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

13 = Inductor #1 phase W Over-temperature Switch

The input monitors three phase line reactor #1, phase W temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

14 = Inductor #2 phase U Over-temperature Switch

The input monitors three phase line reactor #2, phase U temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

15 = Inductor# 2 Phase Over-temperature Switch

The input monitors three phase line reactor #2, phase V temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

16 = Inductor #2 Phase W Over-temperature Switch

The input monitors three phase line reactor #2, phase W temperature. This input is wired to a normally closed snap switch. When mapped to an input, an open circuit will cause the drive to trip with an inductor over-temperature fault.

17 = Sync Down Command

The input is used to command the drive to synchronize to the utility grid in preparation to transfer the motor from the utility grid to drive. The drive must by in sync transfer mode for this command to function.

18 = Sync Up Command

The input is used to command the drive to synchronize to the utility grid in preparation to transfer the motor from the drive to utility grid. The drive must by in sync transfer mode for this command to function.

19 = Sync Transfer Go Command

The input is used to command the drive to execute a sync transfer operation. The drive and utility grid must be synced before the transfer will occur. The drive must by in sync transfer mode for this command to function.

20 = Motor Select 1

Input is used to select the motor number (0 or 1) for a multiple motor sync-transfer drive. The drive must be in sync-transfer mode for Motor Select bits to function. Off selects motor 1, on selects motor 2.

21 = Filter Air Temperature

Reserved

22 = Main Blower Auxiliary Contact 1

Auxiliary contact monitor for main blower starter bank 1. This input is used to monitor the state of the starters used for main blower control. This input can be used alone or in addition to the main blower flow sensors. The normally open auxiliary contact of all main blower starters should be wired in series, and connected to this input. If the contact is open when the main blowers are commanded to run, a fault will occur, or use of redundant blowers will be attempted.

23 = Main Blower Auxiliary Contact 2

Auxiliary contact monitor for main blower starter bank 2. This input is used to monitor the state of the starters used for main blower control. This input can be used alone or in addition to the main blower flow sensors. The normally open auxiliary contact of all main blower starters should be wired in series, and connected to this input. If the contact is open when the main blowers are commanded to run, a fault will occur, or use of redundant blowers will be attempted.

24 = Redundant Blower Auxiliary Contact 1

Auxiliary contact monitor for redundant blower starter bank 1. This input is used to monitor the state of the starters used for redundant blower control. This input can be used alone or in addition to the redundant blower flow sensors. The normally open auxiliary contact of all redundant blower starters should be wired in series, and connected to this input. If the contact is open when the main blowers are commanded to run, a fault will occur.

G1.16.5 Analog Input (Base 1)

Selects the function used for an analog input module on Turck base 1 (Example: An In1AFunc selects the function of input module 1, input A). When an input is mapped to one of the functions listed, the corresponding protection mode is automatically enabled. If a function is not mapped to an input point, the protection mode is disabled.

Available functions:

0 = None
1 = Main Blower1 Flow (Optional)
2 = Redundant Blower 1 Flow (Optional)
3 = Main Blower2 Flow (Optional)
4 = Redundant Blower 2 Flow (Optional)
5 = Main Blower3 Flow (Optional)
6 = Redundant Blower 3 Flow (Optional)
7 = Main Blower4 Flow (Optional)
8 = Redundant Blower 4 Flow (Optional)
9 = Main Blower5 Flow (Optional)
10 = Redundant Blower 5 Flow (Optional)
11 = Main Blower6 Flow (Optional)
12 = Redundant Blower 6 Flow (Optional)
13 = Main Blower7 Flow (Optional)
14 = Redundant Blower 7 Flow (Optional)
15 = Inlet Air Temperature
16 = Exhaust Air Temperature
17 = Transformer Core Temperature
18 = Transformer Left Coil Temperature
19 = Transformer Center Coil Temperature
20 = Transformer Right Coil Temperature
21 = Inverter 1 Phase U Balancing Reactor Temperature
22 = Inverter 1 Phase V Balancing Reactor Temperature
23 = Inverter 1 Phase W Balancing Reactor Temperature
24 = Inverter 2 Phase U Balancing Reactor Temperature
25 = Inverter 2 Phase V Balancing Reactor Temperature
26 = Inverter 2 Phase W Balancing Reactor Temperature
27 = Inverter 1 Exhaust Temperature
28 = Inverter 2 Exhaust Temperature
29 = Rectifier Exhaust Temperature 1
30 = Rectifier HeatSink1 Temperature
31 = Rectifier HeatSink1 Temperature
32 = Sine Filter Fain Flow
33 = Inverter 1 RTD1 Temperature
34 = Inverter 1 RTD2 Temperature
35 = Inverter 1 RTD3 Temperature
36 = Inverter 1 RTD4 Temperature
37 = Inverter 1 RTD5 Temperature
38 = Inverter 1 RTD6 Temperature
45 = Discharge Resistor RTD Temperature (gjv check this, non-contiguous may be a problem)

G1.16.6 Analog Input (Base 2)

Selects the function used for an analog input module on Turck base 2 (Example: An In1AFunc selects the function of input module 1, input A). When an input is mapped to one of the functions listed, the corresponding protection mode is automatically enabled. If a function is not mapped to an input point, the protection mode is disabled.

Available functions:

0 = None
1 = Main Blower1 Flow (Optional)
2 = Redundant Blower 1 Flow (Optional)
3 = Main Blower2 Flow (Optional)
4 = Redundant Blower 2 Flow (Optional)
5 = Main Blower3 Flow (Optional)
6 = Redundant Blower 3 Flow (Optional)
7 = Main Blower4 Flow (Optional)
8 = Redundant Blower 4 Flow (Optional)
9 = Main Blower5 Flow (Optional)
10 = Redundant Blower 5 Flow (Optional)
11 = Main Blower6 Flow (Optional)
12 = Redundant Blower 6 Flow (Optional)
13 = Main Blower7 Flow (Optional)
14 = Redundant Blower 7 Flow (Optional)
15 = Inlet Air Temperature
21 = Inverter 1 Phase U Balancing Reactor Temperature
22 = Inverter 1 Phase V Balancing Reactor Temperature
23 = Inverter 1 Phase W Balancing Reactor Temperature
24 = Inverter 2 Phase U Balancing Reactor Temperature
25 = Inverter 2 Phase V Balancing Reactor Temperature
26 = Inverter 2 Phase W Balancing Reactor Temperature
27 = Inverter 1 Exhaust Temperature
28 = Inverter 2 Exhaust Temperature
29 = Rectifier Exhaust Temperature 1
30 = Rectifier HeatSink1 Temperature
31 = Rectifier HeatSink1 Temperature
32 = Sine Filter Fain Flow
33 = Inverter 1 RTD1 Temperature
34 = Inverter 1 RTD2 Temperature
35 = Inverter 1 RTD3 Temperature
36 = Inverter 1 RTD4 Temperature
37 = Inverter 1 RTD5 Temperature
38 = Inverter 1 RTD6 Temperature
45 = Discharge Resistor RTD Temperature (remap in source)

Description of Analog Input Functions

0 = None

1 = Main Blower 1 Flow Sensor (Optional)

Input used to measure main blower 1 air flow rate, in linear feet per minute (lfpm).

2 = Redundant Blower 1 Flow Sensor (Optional)

Input used to measure redundant blower 1 air flow rate, (lfpm).

3 = Main Blower 2 Flow Sensor (Optional)

Input used to measure main blower 2 air flow rate, (lfpm).

4 = Redundant Blower 2 Flow Sensor (Optional)

Input used to measure redundant blower 2 air flow rate, (lfpm).

5 = Main Blower 3 Flow Sensor (Optional)

Input used to measure main blower 3 air flow rate, (lfpm).

6 = Redundant Blower 3 Flow Sensor (Optional)

Input used to measure redundant blower 3 air flow rate, (lfpm).

7 = Main Blower 4 Flow Sensor (Optional)

Input used to measure main blower 4 air flow rate, (lfpm).

8 = Redundant Blower 4 Flow Sensor (Optional)

Input used to measure redundant blower 4 air flow rate, (lfpm).

9 = Main Blower 5 Flow Sensor (Optional)

Input used to measure main blower 5 air flow rate, (lfpm).

10 = Redundant Blower 5 Flow Sensor (Optional)

Input used to measure redundant blower 5 air flow rate, (lfpm).

11 = Main Blower 6 Flow Sensor (Optional)

Input used to measure main blower 6 air flow rate, (lfpm).

12 = Redundant Blower 6 Flow Sensor (Optional)

Input used to measure redundant blower 6 air flow rate, (lfpm).

13 = Main Blower 7 Flow Sensor (Optional)

Input used to measure main blower 7 air flow rate, (lfpm).

14 = Redundant Blower 7 Flow Sensor (Optional)

Input used to measure redundant blower 7 air flow rate, (lfpm).

15 = Cabinet Inlet Temperature

Input used to measure air temperature at air inlet.

16 = Cabinet Exhaust Temperature

Input used to measure the cabinets exhaust temperature. When the temperature of this point exceeds 70 deg C, the drive will trip.

17 = Transformer Core Temperature

Input used to measure the transformer core temperature. When the temperature of this point exceeds the value of 'TransformerCore", P1.11.1.3 the drive will trip on 'XfmrOTCore'.

18 = Transformer Left Coil

Input used to measure the transformer coil temperature. When the temperature of this point exceeds the value of 'TransformerCoil", P1.11.1.4 the drive will trip on 'XfmrOTCoil'.

19 = Transformer Middle Coil

Input used to measure the transformer coil temperature. When the temperature of this point exceeds the value of 'TransformerCoil", P1.11.1.4 the drive will trip on 'XfmrOTCoil'.

20 = Transformer Right Coil

Input used to measure the transformer coil temperature. When the temperature of this point exceeds the value of 'TransformerCoil", P1.11.1.4 the drive will trip on 'XfmrOTCoil'.

21 = Inverter 1 Balancing Reactor Phase U Temperature

Monitors the temperature of inverter 1 phase U balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

22 = Inverter 1 Balancing Reactor Phase V Temperature

Monitors the temperature of inverter 1 phase V balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

23 = Inverter 1 Balancing Reactor Phase W Temperature

Monitors the temperature of inverter 1 phase W balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

24 = Inverter 2 Balancing Reactor Phase U Temperature

Monitors the temperature of inverter 2 phase U balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

25 = Inverter 2 Balancing Reactor Phase V Temperature

Monitors the temperature of inverter 2 phase V balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

26 = Inverter 2 Balancing Reactor Phase W Temperature

Monitors the temperature of inverter 2 phase W balancing reactor. When the temperature of this point exceeds the value of 'Reactor/Inductor', P1.11.1.7 the drive will trip on 'ReactorOT'.

27 = Inverter 1 Exhaust Temperature

Monitors the temperature of inverter 1 exhaust. When the temperature of this point exceeds the value of 70 degrees C the drive will indicate an exhaust temperature warning. This measurement is also used in the blower control logic that monitor the cabinet inlet/exhaust temperature delta.

28 = Inverter 2 Exhaust Temperature

Monitors the temperature of inverter 2 exhaust. When the temperature of this point exceeds the value of 70 degrees C the drive will indicate an exhaust temperature warning. This measurement is also used in the blower control logic that monitor the cabinet inlet/exhaust temperature delta.

29 = Rectifier Exhaust Temperature

Monitors the temperature of Rectifier exhaust. When the temperature of this point exceeds the value of 70 degrees C the drive will indicate an exhaust temperature warning. This measurement is also used in the blower control logic that monitor the cabinet inlet/exhaust temperature delta.

30 = Rectifier 1 Temperature

Monitors the temperature of rectifier Heatsink 1. When the temperature of this point exceeds P1.11.1.6, 'BridgeRectifier', the drive will fault on 'RectifierOT'.

31 = Rectifier 2 Temperature

Monitors the temperature of rectifier Heatsink 2. When the temperature of this point exceeds P1.11.1.6, 'BridgeRectifier', the drive will fault on 'RectifierOT'.

G1.17 SYNCH TRANSFER

P1.17.1 PHASE

P1.17.1.1 Sync Transfer Mode

0 = Disable Sync Transfer Mode
1 = Enable Sync Transfer Mode

P1.17.1.2 Sync Accel Time

Sets the acceleration rate used when synchronizing the VFD out to the utility grid.

P1.17.1.3 Sync Decel Time

Sets the decceleration rate used when synchronizing the VFD out to the utility grid.

P1.17.1.4 Sync Up Angle

Set the phase relationship of the drive output to utility grid for final synchronization, when transferring from the VFD to utility. Example -30 means the drive lead utility by 30 degrees when synchronization is attained.

P1.17.1.5 Sync Down Angle

Set the phase relationship of the drive output to utility grid for final synchronization, when transferring from the utility to VFD. Example -30 means the drive lead utility by 30 degrees when synchronization is attained.

P1.17.1.6 Angle Zero Adjust

Zero offset null for synchronizer PID.

P1.17.1.7 Sync Gain

Proportional gain term for phase synchronizer PID.

P1.17.1.8 Phase Divider

Reserved

P1.17.1.9 Phase Dead band

Dead band used for phase lock in degrees.

P1.17.1.10 Frequency Dead band

Deadband used for frequency lock in degrees

P1.17.2 SEQUENCE

Note on Bypass and Output contactor control:

There are two styles of contactor that can be used in sync transfer systems; maintained hold, and latch-unlatch. The remote I/O menu output section has options for both types of devices. For maintained hold devices, only one output is required, and that output is on as long as the contactor is supposed to be on. For latched devices, two outputs are required, one to latch the contactor, and the other to unlatch it. The synch transfer logic uses on times for the latch and unlatch signals of 1 second. The signal are output at the appropriate times to close and open latch/unlatch style devices.

P1.17.2.1 Sync-Up Inverter Stop

Time in milliseconds from the 'TransferGo' signal going active to inverter modulation stop.

P1.17.2.2 Sync up Bypass Close

Time in milliseconds from the "TransferGo" signal going active to closure of 'BypassLatch' or 'BypassMaintained'.

P1.17.2.3 Sync Up Output Open

Time in milliseconds from the "TransferGo" signal going active to closure of 'Output Unlatch' or opening of 'Output Maintained'.

P1.17.2.4 Sync Down Bypass Open

Time in milliseconds from the "TransferGo" signal going active to closure of'BypassUnLatch' or opening of 'Bypass Maintained' .

P1.17.2.5 Sync Down Output Close

Time in milliseconds from the "TransferGo" signal going active to closure of 'Output Latch' or closing of 'Output Maintained'.

P1.17.2.6 Sequence Complete

Time in milliseconds from the "TransferGo" signal going active to the transfer sequence timer resetting. This signal can be used by the PLC to acknowledge that the transfer sequence has completed.

P1.17.1 TIMERS

P1.17.3.1 SyncAquireTime

Maximum time allowed for sync lock to occur after 'transferUp" or 'transferDown' input is asserted. This time includes the ramp time if the transfer go signal is given at a frequency that is lower than the utility grid.

P1.17.3.2 SyncLockTime

Minimum time required for synclock to be held before 'syncAck' output is asserted. Longer times provide a more settling time for solid phase lock.

P1.17.3.3 Frequency Dead Band On Delay

Sets the on time delay used by the debounce logic at the output of the frequency lock comparator. The comparator dead band is set by parameter P1.17.1.10 Frequency Dead band.

P1.17.3.4 Frequency Dead Band Off Delay

Sets the off time delay used by the debounce logic at the output of the frequency lock comparator. The comparator dead band is set by parameter P1.17.1.10 Frequency Dead band.

P1.17.3.5 Phase DeadBand On Delay

Sets the on time delay used by the debounce logic at the output of the frequency lock comparator. The comparator dead band is set by parameter P1.17.1.9 Phase Dead band.

P1.17.3.6 Phase DeadBand Off Delay

Sets the on time delay used by the debounce logic at the output of the frequency lock comparator. The comparator dead band is set by parameter P1.17.1.9 Phase Dead band.

Special Parameters

The following parameter ID's are useful for monitoring the status of the SC9000 EP drive. The parameter ID can be used with SC9000 EP fieldbus interfaces to obtain data from these parameters.

Parameter ID 1995: - CSpecFaultBits1

B0 = Check Filter Alarm
B1 = Not Faulted
B2 = gjv check this one
B3 = Estop Fault Active
B4 = Output Contactor Fault Active
B5 = Ambient Temperature Warning
B6 = Exhaust Hot Warning
B7 = Faulted
B8 = Transformer Core OT Warning
B9 = Transformer Coils OT Warning
B10 = Inverter Over Temperature Warning
B11 = SPARE
B12 = SPARE
B13 = Main Blower Warning
B14 = Redundant Blower Warning
B15 = Blower Lost Fault

Parameter ID NNNN: V4FaultReg1

B0 = Inverter OT Fault
B1 = Inverter OT Warning
B2 = Bridge Rectifier OT Fault
B3 = Bridge Rectifier OT Warning
B4 = Redundant Blower Warning
B5 = Main Blower Warning
B6 = Blower Loss Fault
B7 = Transformer Left Fault
B8 = xfmr5_HiTemp.WARNACT;
B9 = xfmr6_HiTemp.FAULTACT;
B10 = xfmr6_HiTemp.WARNACT;
B11 = xfmr7_HiTemp.FAULTACT;
B12 = xfmr7_HiTemp.WARNACT;
B13 = xfmr8_HiTemp.FAULTACT;
B14 = xfmr8_HiTemp.WARNACT;
B15 = FALSE;

Parameter ID NNNN: RemoteInputBits1

B0 = Phase Monitor Relay
B1 = Reserved
B2 = Isolation Interlock
B3 = Auxiliary E Stop
B4 =Remote E Stop
B5 = Main Contactor Auxiliary
B6 = Bypass Contactor Auxiliary
B7 = Output Contactor Auxiliary
B8 = Sine Filter Capacitor Over Pressure
B9 = Sine Filter Inductor or Air OT
B10 = Balancing Reactor Inverter 1 Phase U Snap Switch
B11 = Balancing Reactor Inverter 1 Phase V Snap Switch
B12 = Balancing Reactor Inverter 1 Phase W Snap Switch
B13 = Balancing Reactor Inverter 2 Phase U Snap Switch
B14 = Balancing Reactor Inverter 2 Phase V Snap Switch
B15 = Balancing Reactor Inverter 2 Phase W Snap Switch

Parameter ID NNNN: U_MRS Motor Regulator Status Bits

B0 = Motoring Current Limit
B0 = Generator Current Limit
B0 = Motoring Torque Limit
B0 = Generator Torque Limit
B0 = Over Voltage Limit
B0 = Under Voltage Limit
B0 = AFE Current Limit

Parameter ID 0043: General Status

B0 MVD_Ready
B1 RunEnable
B2 RunRequest
B3 MC_Run
B4 MC_Fault
B5 MC_Warning
B6 MC_DC_Brake **Inactive in V4.12**
B7 MotorRegulatorStatus
B8 IOTerminalControl
B9 KeypadControl
B10 FieldbusControl
B11 InLocal
B12 InRemote
B14 FBReferenceActive
B15 HeartBeat (1Second) **Inactive in V4.12**

B0 MVD_Ready

In the SC9000 EP, the DC bus does not charge until the drive is started. For this reason, the 'MC_READY' bit used in the low voltage drives was replaced with 'MVD_Ready'. This bit instead indicates that the main isolation switch is closed, the status of the phase monitor relay is good, and that the drive is not faulted.

B1 through B12 Control Source Status Bits

In the low voltage drive, there was a disconnect between the control place and the selected keypad mode. It was possible to check whether the drive was in local or remote, but the user had to know what the local and remote control places were in advance in order to determine in control was from the keypad, I/O terminals, or fieldbus. In the SC9000 EP, there are separate bits to indicate the control place as well as the actual physical location the control is coming from.

Chapter 6: Pre-Start Checks

⚠ CAUTION

Prior to initial operation of the SC9000 EP, the system must be inspected, adjusted and tested by qualified personnel. Failure to properly inspect, adjust, and test the drive before initial startup can result in equipment damage that is not covered by the manufacturer's warranty.

General Inspection

⚠ CAUTION

All power sources must be isolated and locked out before servicing the equipment.

Open the panels and/or doors and inspect for any physical damage or remaining installation debris on the SC9000 EP power system.

Inspect the control rack to verify that there are no loose connectors on the control cards.

Check that the SC9000 EP is wired correctly and all power connections are tight. Verify that all control wiring and plug-in terminal blocks are tight. Field wiring should be checked for clearance to live busses where necessary, physically secured to withstand the effects of fault current.

Check that there are no obstructions in the intake airway or exhaust airway.

Using an ohmmeter, check for and eliminate any grounds between the drive input and output power leads.

Verify that the emergency stop pushbutton on the low voltage door is depressed and in the stop state. Verify that all remote start/stop signals are in the stop position to ensure that the motor does not attempt to start when the drive isolation switch is closed and the main contactor is energized.

Ensure that safety signs are not covered or obscured by paint.

All switches and other operating mechanisms should be manually exercised to make certain that they are properly aligned and operate freely.

Operating mechanisms such as interlocks, key switches, etc., should be checked for function as intended for protection of personnel and equipment.

All devices must be set to their normal or OFF position before energizing incoming power.

Motor

Verify that the motor nameplate data and load requirements correspond to SC9000 EP output ratings:

- Voltage: If motor is re-connectable, verify that the leads are configured for the correct voltage and phase rotation
- Frequency: Verify that the motor is 60 Hz and matches the SC9000 EP rating
- Duty Cycle: Verify that the duty cycle matches the load requirements
- Check that the motor is installed according to the manufacturer's instructions
- Manually rotate the motor shaft to check that the motor is not binding

Transformer

Verify that the actual input voltage being fed to the drive transformer primary is within ±10% of the rated voltage listed on the drive nameplate.

Grounding

Verify that the drive ground bus is properly grounded to the site ground with the proper sized conductor. Connections must be tightened to the proper torque. All grounding connections should be checked.

Verify that the shield of all shielded control and signal wires that plug into the control rack cards are grounded at the rack using the grounding clamp.

Close all panels and/or doors before energizing the SC9000 EP.

Chapter 7: Operation

Safety Interlocks

The SC9000 EP is manufactured with several built-in interlock provisions and safety features to reduce hazards and provide proper operating sequences:

- Mechanical interlocks prevent opening the medium voltage doors with the switch in the closed position. Ensure that the medium voltage doors are fully closed and latched to prevent damage to the interlock bracket on the back of the incoming structure door
- An additional interlock prevents closing of the switch unless the medium voltage door is closed (see Medium Voltage Door Interlock Plunger in **Figure 19**)
- Standard key interlocks on all medium voltage doors. On SC9000 EPs that require two or more structures, the adjacent door(s) will also be interlocked with the switch operating mechanism. The adjacent door(s) must be closed before the main door is closed. All doors must be closed before the switch operator can be moved to the closed position

Note: Attempting to close the switch with the door open can cause damage to the operating mechanism.

Mechanical and electrical interlocks are provided to ensure that the non-loadbreak isolation switch cannot be opened or closed unless the main contactor is de-energized (see mechanical interlock with contactor in **Figure 19**). Do not attempt to force the switch operating mechanism with the main contactor closed. The handle mechanism is designed to fail before the isolation switch can be opened with the main contactor closed.

⚠ CAUTION

Applying excessive force to the switch handle with the mechanical interlocks engaged will result in damage to the switch.

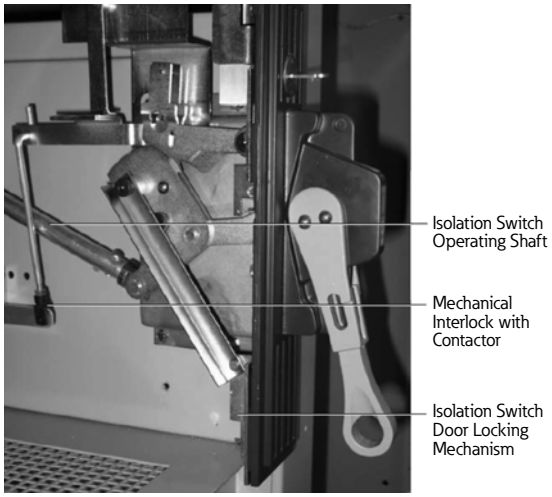
An electrical interlock is provided to disconnect the control power transformer secondary before the isolating switch stabs are disconnected from the line fingers. This interlock ensures that the switch is breaking transformer magnetizing current only. Do not connect additional loads to the isolating switch.

⚠ WARNING

If loads greater than the interrupting rating of the switch are connected to the switch, equipment damage, personal injury or death may occur.

An optional key interlock may be provided to lock the switch in the open position for special configurations. Refer to the specific order drawings to determine if key interlocks have been provided.

Figure 19. Handle Mechanism with Contactor and Door Interlocks



Isolation Switch

The drive isolation switch is a non-loadbreak device. Mechanical and electrical interlocks are provided to ensure that the main contactor is de-energized before the switch can be operated. In the open position, the switch isolates medium voltage from the main compartment, allowing access to the drive for inspection and maintenance. The isolation switch includes ground fingers that ground the line side of the power fuses when the switch is in the open position.

The switch consists of a fixed rear portion and a removable front portion. Refer to **Figures 20** and **21**. The fixed portion includes line fingers and a moveable shutter that isolates the line fingers when the switch is in the open position. The removable portion is operated by a handle mechanism that extends through the medium voltage door. With the handle in the up position, the switch is closed and medium voltage is available for full operation of the controller load. With the handle in the down position, the switch is open and medium voltage is isolated from the downstream components.

An isolation switch viewing window is provided in the medium voltage door directly in front of the isolation switch. After opening the isolation switch and before opening the medium voltage door, the switch should be visually examined through the viewing window to verify that it is in the open position. Three green and white “barber poles” will be visible when the switch is in the open position and the shutter assembly is in the isolating position. See **Figure 22** for location of barber poles. The use of a flashlight will help in verifying the position of the barber poles.

⚠ WARNING

Do not enter the medium voltage drive compartment without visually verifying that the isolation switch is open and the isolating shutter is in place. Entering a compartment without the isolating shutter in place may result in severe injury or death.

Medium voltage may still be present behind the shutter and on the main bus or incoming cables, even with the isolation switch open. The bus or incoming cable connections are barriered from the other drive components. Extreme caution must be exercised to prevent contact with these live parts. Do not remove the barriers or open the shutter unless the upstream feeder is locked out and tagged out.

⚠ WARNING

Do not contact any line side drive connection without verifying that the upstream feeder is properly locked out. Failure to lockout the upstream feeder may result in severe injury or death.

Figure 20. Isolation Switch

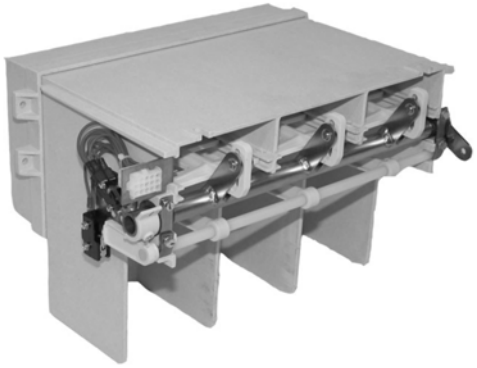


Figure 21. Shutter Mechanism and Finger Barrier Isolation of Incoming Line Bus (Shown With Removable Portion of Isolation Switch Removed)

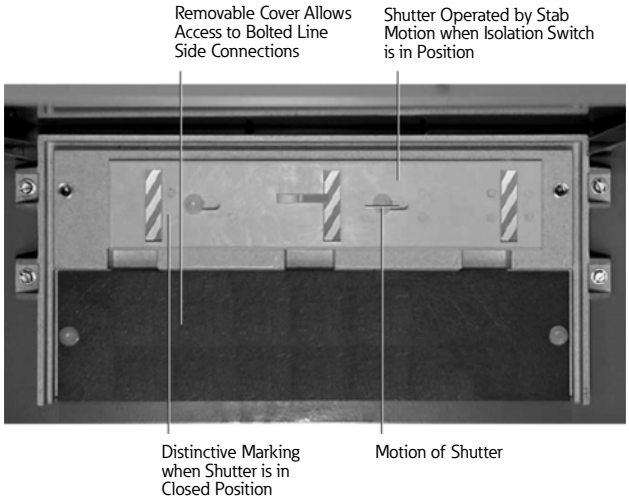
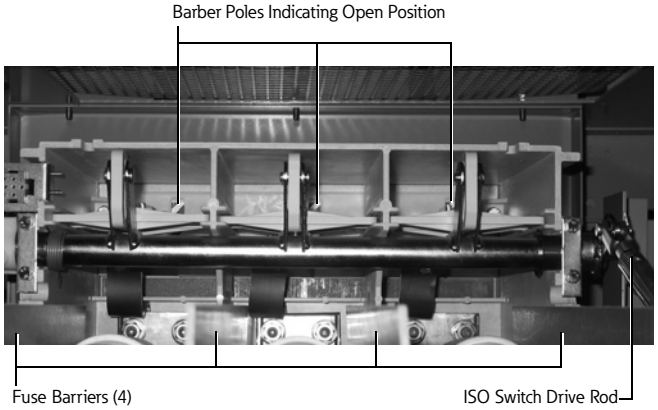

Removable Cover Allows Access to Bolted Line Side Connections
Shutter Operated by Stab Motion when Isolation Switch is in Position
Distinctive Marking when Shutter is in Closed Position
Motion of Shutter

Figure 22. Shutter Mechanism and Finger Barrier Isolation of Incoming Line Bus (Shown With Removable Portion of Isolation Switch)



Main Contactor Assembly

400A Vacuum Contactor

A stab-in version of the SL Contactor is standard. The stab-in contactor is mounted on wheels and rolls into the SC9000 EP AFD structure. Contactor line and load fingers engage cell-mounted stabs as the contactor is inserted into the SC9000 EP AFD incoming cell. The contactor is held in position by a bolt and bracket combination. It can be easily withdrawn from the SC9000 EP AFD incoming cell by removing the bolt holding the contactor against the bracket and disconnecting the isolation switch interlock. The contactor can be removed from the SC9000 EP AFD after disconnecting the medium voltage cables going to the control transformer.

800A Vacuum Contactor

The 800A SL Contactor is available in the SC9000 EP Frames D and E AFD and is rated at 720A enclosed.

The 800A contactor is also stab-in. The 800A contactor is mounted on wheels and has similar features to the stab-in 400A contactor.

Figure 23. 400A Stab-in Contactor and Fuse Assembly

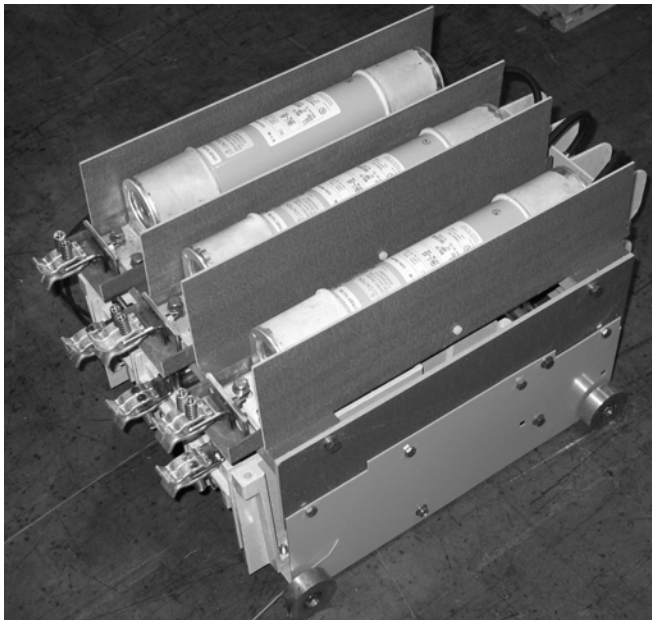
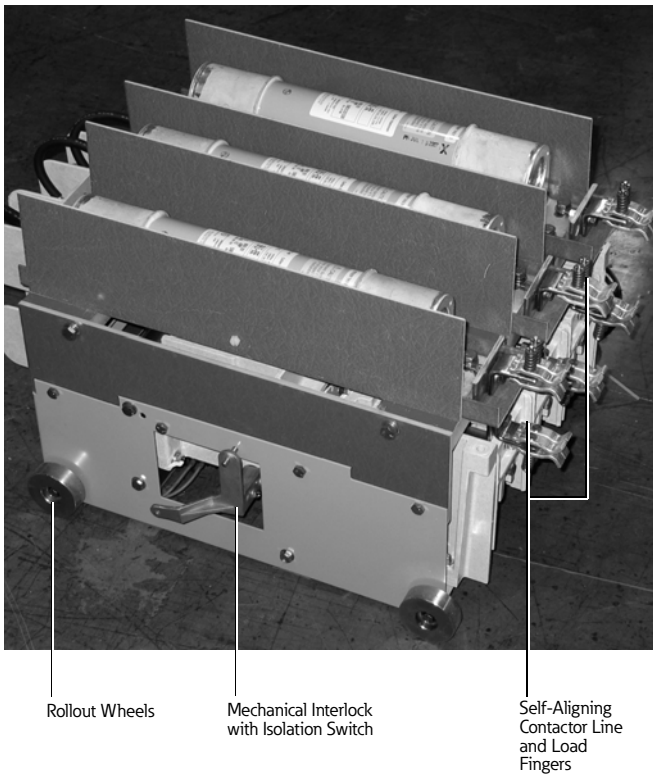


Figure 24. Stab-in Contactor Mechanical Interlock and Fingers



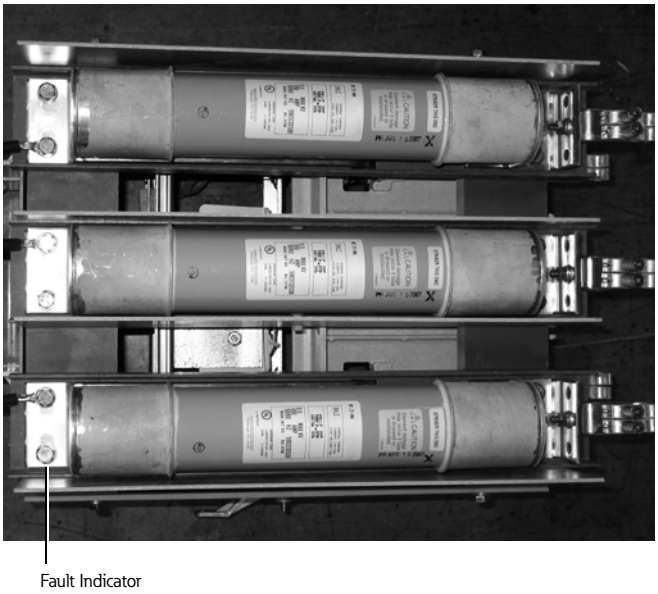
Current Limiting Fuses

SC9000 EP AFDs use Eaton Type HLE power fuses with special time/current characteristics. The fuse is coordinated with the contactor to provide maximum motor/transformer utilization and protection. The standard mounting method for power fuses is bolted onto the contactor assembly.

Interruption is accomplished without expulsion of gases, noise or moving parts. Type HLE fuses are mounted in a horizontal position. When a fault has been cleared, a metal pin indicator in the front of the fuse, normally depressed, pops up to give visible blown fuse indication.

The control circuit primary fuses are also current limiting.

Figure 25. Blown Fuse Indicating Device



Contactor Operation

The main contactor does not need to be closed to apply pre-charge; however, the isolation switch must be closed. The main contactor must be closed to apply power to the isolation transformer and rectifier. The main contactor must be open before operating the isolation switch. Start and Stop pushbuttons are standard on the keypad, and open and close pushbuttons may also be supplied on the drive low voltage door. The control power transformer will provide 120 Vac to power the drive control modules.

Isolated Low Voltage Control

The low voltage door has four cutouts as standard.

Figure 26. SC9000 EP AFD Low Voltage Door Closed

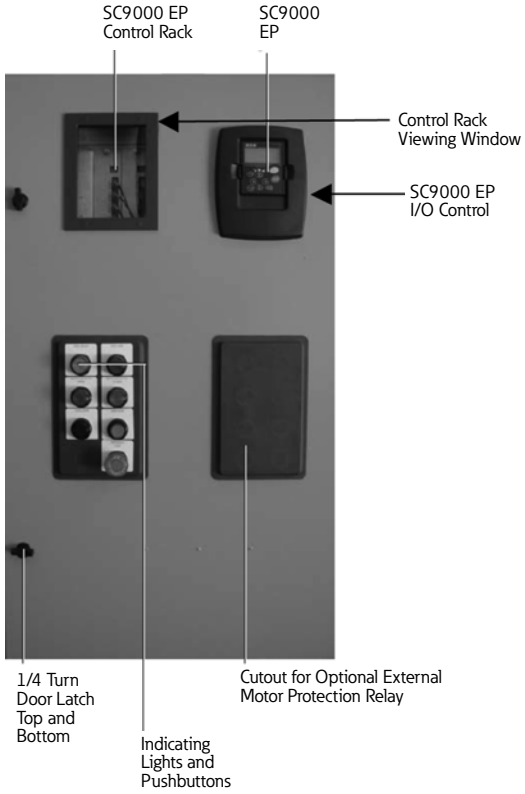
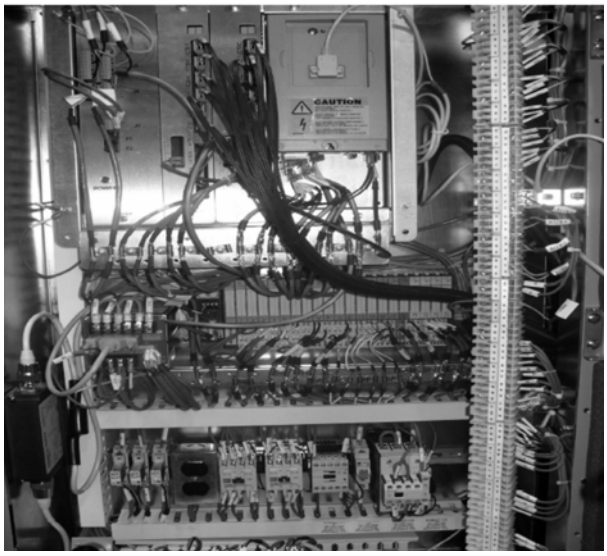

SC9000 EP Control Rack
SC9000 EP
Control Rack Viewing Window
SC9000 EP I/O Control
1/4 Turn Door Latch Top and Bottom
Indicating Lights and Pushbuttons
Cutout for Optional External Motor Protection Relay

Figure 27. SC9000 EP AFD Low Voltage Door Open

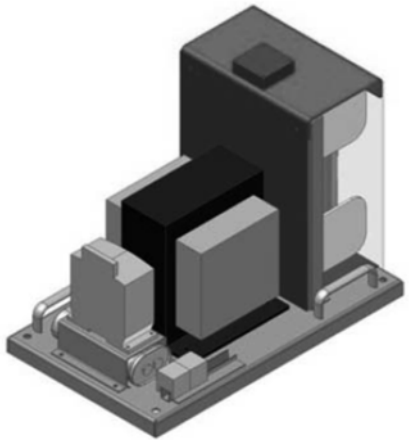


The Device Panel and optional Eaton MP Series Motor Protection Relays fit in the same size low voltage door cutout. The standard SC9000 EP keypad can be removed for plug-in of a laptop via a serial connection. A standard viewing window in the low voltage door allows visual verification of the SC9000 EP AFD status. The low voltage control panel is behind the low voltage door and is completely isolated from the medium voltage compartment. The medium voltage door is locked closed and interlocked with the isolation switch. A row of control terminal blocks is provided on the right side of the control compartment. Opening the low voltage door can access them. The blocks are fixed mounted and remain in place when the medium voltage door is opened. A test plug is supplied inside the low voltage section. The plug is wired to the secondary of the control power transformer. Test power can be used to energize the control circuit by using a standard extension cord to energize the plug. A 15A maximum customer convenience two-receptacle outlet is also provided for powering a laptop or other electronic devices. The low voltage compartment swings out of the way with the medium voltage door as it is opened, allowing access to the medium voltage components that are mounted behind the low voltage compartment.

Pre-Charge Circuit

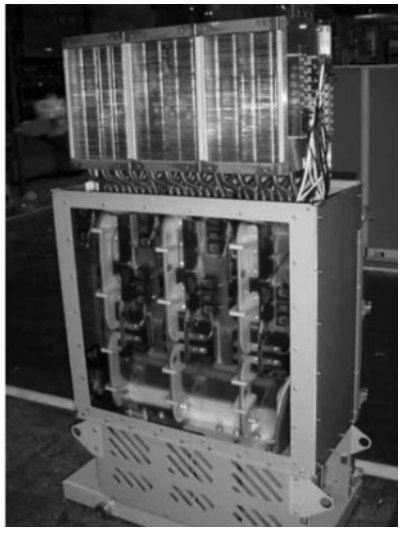
Unlike other pre-charge methods, the innovative pre-charge circuit in the SC9000 EP protects the rectifier and DC bus components from high in-rush currents. The design uses the control power circuit for DC link capacitor charging. This feature eliminates the risk of component or transformer failure during the pre-charge cycle and lengthens the life of the affected components.

Figure 28. SC9000 EP Pre-Charge Circuit



Modular Roll-in/Roll-out Stab-in Three-Phase Inverter

Figure 29. 2500 hp Three-Phase Classic Inverter



The roll-out three-phase inverter module employs an insulation and buswork system to obtain the highest power density rating in the market.

Heat pipe technology is used to cool the active power components in the inverter.

This method of heat removal from the inverter is up to 10 times more efficient than traditional air-cooling methods, resulting in less required airflow for quieter and more efficient operation. The thermal management system has been subjected to temperatures of –50°C to model cold weather transport without the rupture of any heat pipes. It is also important to note that thermal management performance was unaffected by the extreme cold storage.

This cooling methodology and the encapsulation of the medium voltage components result in a harsh-environment inverter that protects the active power devices and circuit boards from the environment and airborne contaminants eliminating potential causes of failures. The encapsulation system also protects other components from flying debris and collateral damage in the event of a device failure.

Figure 30. Heat Pipe Thermal Management System

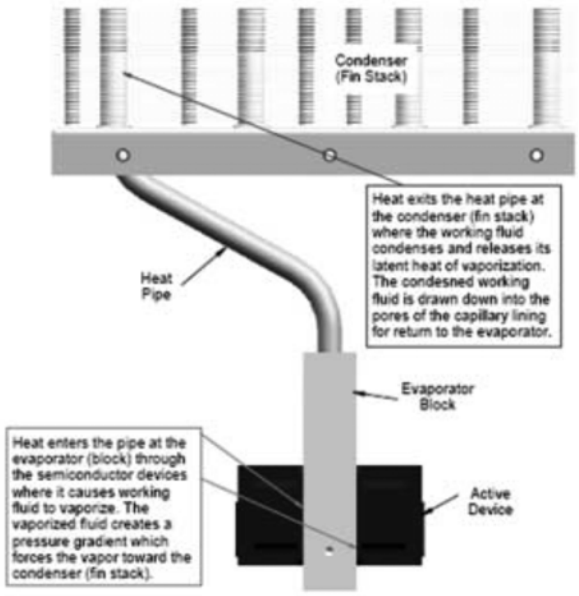
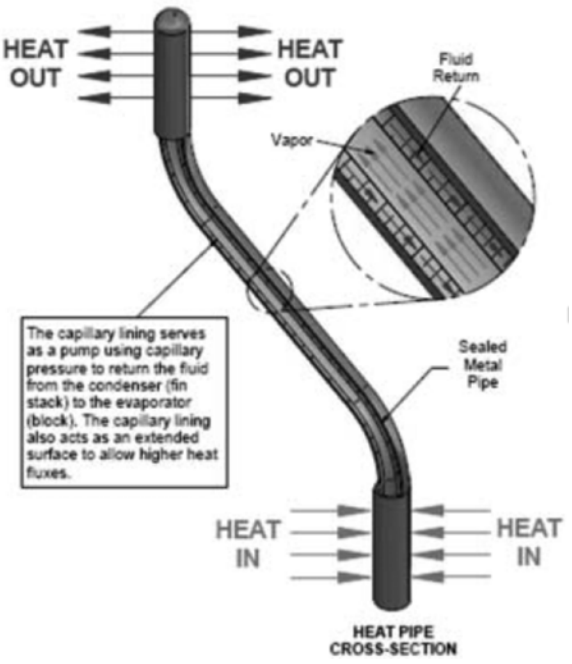

Condenser
(Fin Stack)
Heat exits the heat pipe at the condenser (fin stack) where the working fluid condenses and releases its latent heat of vaporization. The condesned working fluid is drawn down into the pores of the capillary lining for return to the evaporator.
Heat
Pipe
Evaporator
Block
Heat enters the pipe at the evaporator (block) through the semiconductor devices where it causes working fluid to vaporize. The vaporized fluid creates a pressure gradient which forces the vapor toward the condenser (fin stack).
Active
Device

Figure 31. Heat Pipe Construction

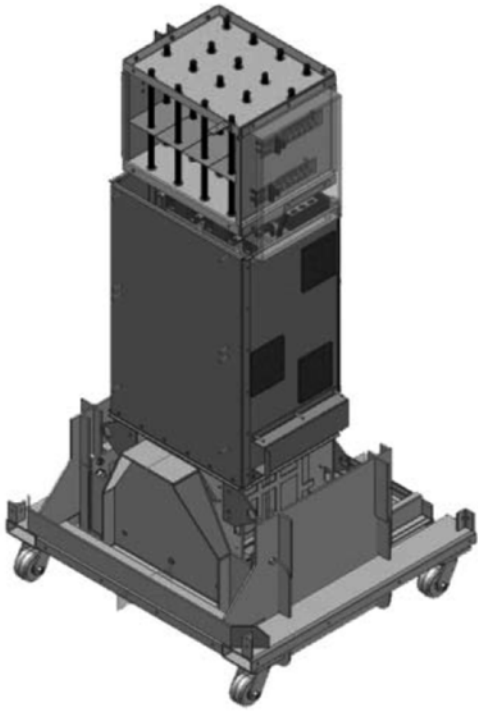


In the event of a failure, the modular roll-in/roll-out design of the inverter will minimize downtime. The SC9000 EP uses an inverter replacement system that minimizes mean-time-to-repair (MTTR) and is designed exclusively for the purposes of inverter module exchange.

The system removes the existing inverter safely and effectively and then allows for the insertion of a replacement inverter that is on-site or shipped from the factory where spare inverters are stocked.

The new and improved power pole inverter encapsulates the power electronics of each half-phase and allows each to be replaced individually rather than replacing the entire inverter.

Figure 32. Inverter Replacement System



Expandable I/O Module

BL20 is a new state-of-the-art system for remotely collecting I/O signals. Historically, I/O signals were brought back to a single large cabinet. This approach is time consuming, costly and inflexible. The modem distributed I/O approach is to use multiple small cabinets placed near the I/O that they control. This allows the machines to be designed in a flexible modular way. It also saves time and money. The BL20 distributed I/O system is specifically designed to address the subtle differences required for this approach. The BL20 consists of three parts: The Gateway, the Base and the Electronic Module. The Gateway is the connection to the I/O network and it is available in many common communications protocols. The Electronic Modules are available in a wide variety of I/O signal types and counts. The Bases provide a complete set of connections for your field devices. In addition to providing I/O connection points, they also distribute, fuse and monitor local power distribution.

Project Configuration

Figure 33. List of Modules (Slices)

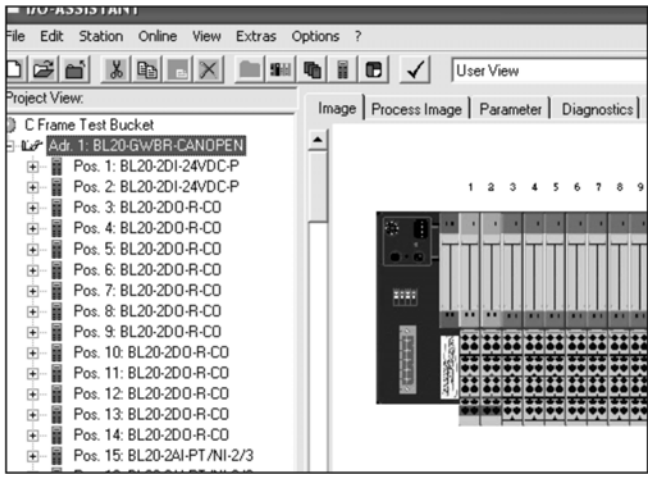


Figure 34. Station View

2.1.1. Station View

User View	Article View and Comment	Short Devic Name
Adr. 1: BL20-GWBR-CANOPEN	-	Turck
1: BL20-2DI-24VDC-P	BL20-S4S-SBBC	
2: BL20-2DI-24VDC-P	BL20-S4S-SBBC	
3: BL20-2DO-R-CO	BL20-S4S-SBBS	
4: BL20-2DO-R-CO	BL20-S4S-SBBS	
5: BL20-2DO-R-CO	BL20-S4S-SBBS	
6: BL20-2DO-R-CO	BL20-S4S-SBBS	
7: BL20-2DO-R-CO	BL20-S4S-SBBS	
8: BL20-2DO-R-CO	BL20-S4S-SBBS	
9: BL20-2DO-R-CO	BL20-S4S-SBBS	
10: BL20-2DO-R-CO	BL20-S4S-SBBS	
11: BL20-2DO-R-CO	BL20-S4S-SBBS	
12: BL20-2DO-R-CO	BL20-S4S-SBBS	
13: BL20-2DO-R-CO	BL20-S4S-SBBS	
14: BL20-2DO-R-CO	BL20-S4S-SBBS	
15: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
16: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
17: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
18: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
19: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
20: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
21: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
22: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
23: BL20-2AI-PT/NI-2/3	BL20-S4S-SBBS	
24: BL20-PF-120/230VAC-D	BL20-P4S-SBBC	
25: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
26: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
27: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
28: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
29: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
30: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
31: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
32: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
33: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
34: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
35: BL20-2DI-120/230VAC	BL20-S4S-SBBC	
36: BL20-2DI-120/230VAC	BL20-S4S-SBBC	

⚠ WARNING

Do not connect test power to the starter control circuit without removing the plug from the receptacle. failure to do so will result in a back-feed condition on the control power transformer, which will generate high voltage inside the controller with the isolation switch open. High voltage can cause severe injury or death.

Drive Control

The drive can be controlled through the keypad on the drive door or by external signals. The keypad is the same unit as is supplied on Eaton's SPX line of low voltage drives. Keypad operation is described in Chapter 5 of this manual.

When all checks have been completed and the drive is ready to run, pull the emergency stop pushbutton on the low voltage door to the "out" position. The drive can now be run via the keypad and/or remote signals.

SC9000 EP Medium Voltage AFD Sequence of Operation

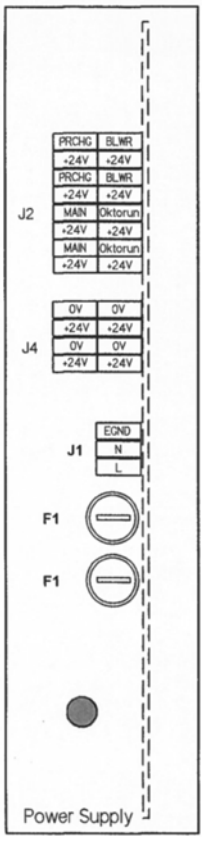
This document contains the sequence of operation for the SC9000 EP Medium Voltage Adjustable Frequency Drive. This is a reference document to understand how the drive operates internally.

BIL	Blue Indicating Light—READY
CPT	Control Power Transformer
DIN	NXP Controller, A9 Option Card Input
DMCR	Drive Motor Control Rack
GIL	Green Indicating Light—OFF (OPEN)
ISW	Isolation Off Load Disconnect Switch
ISWX	Isolation Switch Auxiliary Relay
M	Main Contactor
MCS	Main Contactor Status
MCR	Main Contactor Relay
MP1	LEM DC Bus Voltage Sensor Input
MP2	LEM DC Bus Voltage Sensor Input
MP3	LEM Current Sensor Input(s)
MRR	Master Ready Relay
MX	Main Contactor Coil
NXP	Drive Controller
OPTA9	Option A9 card
PCR	Pre-Charge Ready
PT	Potential Transformer
PX	Pre-Charge Relay
RIL	Red Indicating Light—RUN (CLOSED)
RTD	Resistive Thermal Device
T2	Blower Transformer
27/47	Undervoltage and Phase Rev. Relay

1. Upon completion of the pre-start checks (see Chapter 6) apply line power to main bus of SC9000 EP.
2. Closing isolation switch (ISW) energizes the control power transformer (CPT), blower transformer (T2), and optional potential transformers (PT). The (ISW) auxiliary contacts close coil (ISWX) and provide feedback to the expandable I/O module. The (ISWX) auxiliary contacts close and the green indicating light (GIL) is illuminated implying the main contactor (M) is open.
3. The expandable I/O module and drive motor control rack power supplies are energized converting AC voltage to DC. Once energized, these controllers boot and perform self-checks. The NXP drive controller is connected to the keypad which initially displays "AC On." The expandable I/O module 'Bus' light goes from orange to green after it is initialized, this takes approximately eleven seconds. This module signals the NXP drive controller its status. The drive motor card rack has two seven segment LCD displays that flash '00' double zero [otherwise they cycle through history error codes which can be reset by simultaneously depressing RESET and STOP on the drive keypad for 5 seconds] and the drive motor control rack J2 output energizes the (MRR) relay.
4. Concurrently, the (27/47) relay connected to the secondary of the blower transformer (T2) detects phase voltage level and phase-sequence. The relay settings are adjustable from 80% to 100% with a factory default setting of 80%. A one second de-bounce time delay avoids nuisance trips. This relay is located within the restricted compartments on the blower control panel and is accessible with the drive in a de-energized state. Its auxiliary contact is normally closed [N.C.] and opens when conditions are correct.
5. If NXP drive controller keypad alarms or faults persist, issue a RESET command from the drive keypad, field bus, PC control or remote input (DIN6) of the (OPTA9). The reset command is passed from the NXP drive controller to the drive motor control rack slave interface card SP4 connector via the expandable I/O module output. If the alarm and/or fault indications fail to clear, refer to the troubleshooting portion of the manual.
6. Prior to issuing a START command ensure the RUN ENABLE signal is high into the NXP drive controller (DIN4) option A9 card.
7. Determine which control place will be used and issue a START command from the drive keypad, field bus, PC control or remote input (DIN1) option A9 card; the NXP drive controller (slot A option A9 card output pin 20) energizes the (RUN) relay and a (RUN) auxiliary contact initiates the run sequence in the drive motor control rack slave interface card SP4 connector. The expandable I/O module commands the inverter fans and drive blowers on.
8. The drive motor control rack power supply J2 output energizes the pre-charge ready relay (PCR). The (PCR) auxiliary contact closes the pre-charge contactor coil (PX) beginning the inverter DC bus pre-charge cycle that lasts seven to fifteen seconds. The inverter DC bus voltage is monitored with sensors which provide feedback to the drive motor control rack master interface card (MP1, MP2). The expandable I/O module RUNX signals blinks the blue indicating light (BIL) during bus charging (and discharging). The master and slave interface cards of the drive motor control rack flash alternating '66' and '99' codes, respectively.
9. Once the DC bus level is reached, the drive motor control rack power supply card J2 output energizes the main contactor ready relay (MCR) which further energizes the main contactor coil (MX). The blue indicating light (BIL) is lit continuous. The (MX) coil controller uses a d=1 (100%) duty cycle pulse width modulated (PWM) signal to pull in the DC coils of the main contactor. Once the vacuum bottles close, the PWM duty drops to a holding value of d=0.1 (10%). The green indicating light (GIL) turns off while the red indicating light (RIL) illuminates. The NXP drive keypad displays a 'READY' signal.

10. The expandable I/O module receives main contactor status feedback (MCS). If the conditions remain correct the NXP drive controller issues a run command to the drive motor control racks' master and slave interface cards. A high speed fiber optic link signal passes from the NXP controller slot E option D2 card to the drive motor control rack master interface card initiating the inverter IGBT gating signals. The adjustable frequency drive then behaves as commanded at the reference place (with a set point from one of the analog inputs, keypad, field bus, or PC control). The drive motor control rack master and interface card flash slower alternating '99' and '66' codes. After a brief period (typically 30 seconds) the pre-charge (PCR) relay drops out disabling that circuit.
11. Three LEM hall effect current transducers monitor the drive inverter output, they are connected to (MP3) at the drive motor control rack master interface card. These signals are conditioned with select ballast resistors and unique drive frame size software keys. They help protect the drive and motor from unwanted overcurrent and unbalance conditions.
12. The drive is nominally equipped with main inverter fans and blowers with optional redundant equivalents. The condition of the blower air-flow sensors (optional) and (RTD) temperature feedback determine which set operates and whether the drive is in an alarm or fault state. The expandable I/O module (RTD) feedback includes sensors from the: ambient air incoming filter, exhaust above transformer air, three transformer coil and one transformer core, and three inverter heat sink locations near U V W phases.

Figure 35. Power Supply Front View



Hardware Components

Power Supply

The power supply is designed to supply the power for the entire control rack. It also contains outputs to control relays for the Main Contactor, Pre-charge, Fan Blowers and 24V Run Signal. It is designed with 3 oz cooper outer layers and 1 ounce copper inner layers.

DC Bus Feedback 0V–GND

Table 10. Power Supply Inputs

Inputs	Description
J1	90–120 Vac or 180–264 Vac
J4	24V—Output
F1/F2	Fuses

Table 11. Relay Connector Outputs

Inputs	Description
J2	MCR—Main Contactor Relay
J2	PCR—Pre-Charge Relay
J2	MR—Main Contactor Relay
J2	24V Run—24V Run Signal

Motor Interface Card

The interface card provides the connection between the controller board and the control rack back plane.

Figure 36. Motor Connector PCB

Table 12. Motor Connector PCB Components

Block	Description
1	DC Feedback Scaling
2	EEPROM
3	±12 Vdc Power Supply

Figure 37. Controller

Master Interface Card

Figure 38. Master Interface Card

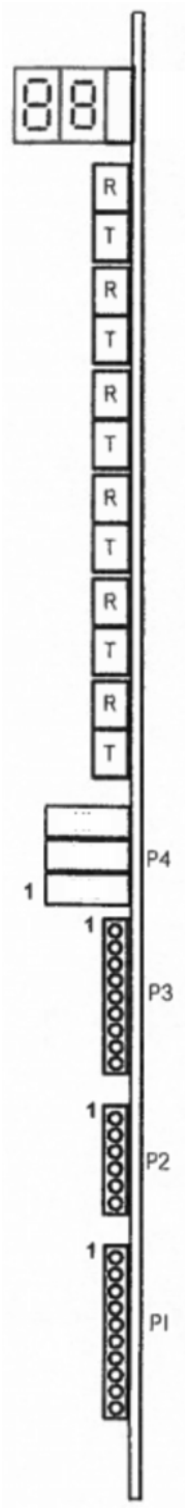


Table 13. MP3—Current Feedback

MP3 Pin	Description	
1	+15V	Phase U
2	M (Signal)	
3	–15V	
4	+15V	Phase V
5	M (Signal)	
6	–15V	
7	+15V	Phase V
8	M (Signal)	
9	–15V	

Table 14. MP2–DC Bus Voltage

MP2 Pin	Description	
MP2 Pin	Description	
1	+15 V	DC Bus Feedback Positive (NVTP)
2	M (Signal)	
3	–15 V	
4	+15 V	DC Bus Feedback Negative (NVTN)
5	M (Signal)	
6	–15 V	

Table 15. MP1–DC Bus Ground

MP1 Pin	Description	
1	NC	
2	0V	DC Bus Feedback 0V–GND
3	NC	
4	0V	DC Bus Feedback 0V–GND
5	NC	
6	NC	
8	NC	
9	Wire	Backplane Connector RTD
10	GND	

Slave Interface Card

Figure 39. Slave Interface Card

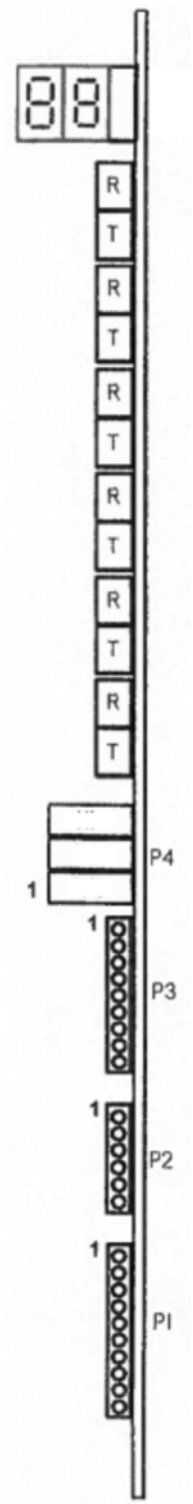


Table 16. SP4—Reset/Run

SP4 Pin	Description
1	RUN
2	RESET
3	Common

Table 17. SP1—RTD Feedback

SP1 pin	Description	
1	ADC1	
2	AGND	
3	ADC2	URTD
4	AGND	
5	ADC3	VRTD
6	AGND	

Chapter 8: Maintenance

A maintenance program should be established as soon as the drive has been installed and put into operation. After the drive has been inspected a number of times at weekly intervals and the conditions noted, the frequency of inspections can be increased or decreased to suit the conditions found.

⚠ WARNING

All incoming power must be disconnected and locked out before performing maintenance on the SC9000 EP. The DC bus voltage must be fully discharged. Failure to disconnect incoming power and verify DC bus is discharged can result in equipment damage, personal injury, or death.

Before attempting maintenance, consult the specific circuit diagrams and other documentation supplied with the drive.

Main Contactor and Fuse Truck

Follow the steps below to remove the contactor/fuse truck from the input cell. Installation is the reverse of the removal process. Note that the mechanical interlock mechanism on the side of the contactor must be reconnected before the contactor can be closed. The mechanism is weighted in such a manner that the contactor cannot operate until the interlock rod clevis is reconnected.

- Disconnect mechanical interlock on right side of contactor
- Unplug Control Harness
- Remove two bolts that mount the front rail on the left side of the contactor to the floor panel
- Swing truck to the left while withdrawing it from cell

Inspect the contactor line and load fingers for signs of arcing or overheating. Replace as necessary. Inspect the mechanical interlock components attached to right side of the contactor main operating shaft and side sheets. Ensure the lever is secure on the shaft and that the pivoting arm moves freely. Verify that the finger assemblies are in their neutral (horizontal) position before reinserting the contactor into the cell. No lubrication is required.

Refer to IB 48018N for details of additional contactor operation and maintenance information.

For installation, reverse the order of the above procedure.

Fuses

Inspect the current limiting fuses after each relay initiated trip, since this is the most severe service to which they will be subjected. Check the fuse resistance, and compare with the value of a new fuse. A pop-up indicator on the visible end of the fuse provides a visual sign of an open fuse. If a fuse has blown due to a fault, it is likely that the other fuses experienced a similar overcurrent condition. In this case, Eaton recommends that all three fuses be replaced. Ensure that the replacement fuses are of the same rating and mounting configuration as those originally supplied.

Isolation Switch

The isolation switch consists of a fixed rear portion and a removable front portion. The switch should operate smoothly in both directions, with an increase in resistance as the stabs engage the controller line fingers. Inspect for any signs of mechanical wear or overheating.

To withdraw the removable portion:

- Remove the main contactor truck assembly
- Remove the control plug
- Remove the cotter pin and clevis pin from drive rod clevis
- Remove the two bolts securing the removable portion of the switch to the fixed portion
- Pull the switch forward, then down and out of the controller

⚠ WARNING

Take care not to let the switch quickly drop down as the removable portion separates from the fixed portion or damage to the shutter can occur.

The fixed portion of the switch including the isolating shutter remains in the controller. Medium voltage may be present at the line fingers behind this shutter. Before attempting to inspect the line fingers or do other work on the fixed portion of the switch, ensure that the controller incoming power is isolated and locked out at an upstream feeder.

With the incoming power locked out, the fingers can be inspected and the vertical bus connections checked for tightness. Remove the polyester barrier mounted immediately below the switch for access to the vertical bus connections. Verify the operation of the shutter mechanism by gently pushing it to the left. It should spring back to the closed position when released.

⚠ WARNING

Failure to lock out incoming power before servicing the fixed portion of the switch or vertical bus can result in equipment damage, severe injury, or death.

Reinstallation is the reverse of the procedure above. Make sure that the shaft of the removable portion of the switch is rotated to the fully open position before reinstallation.

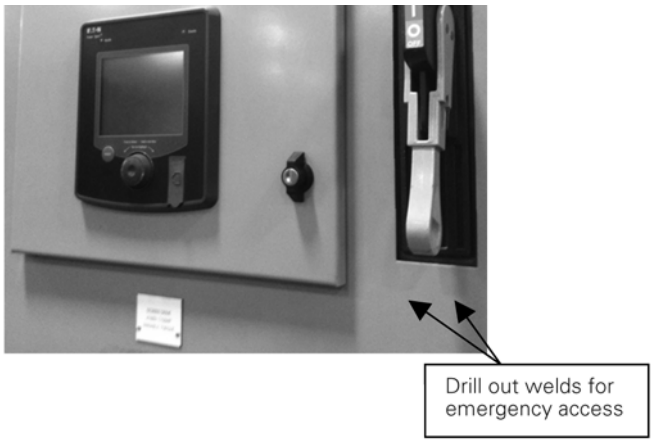
⚠ WARNING

If the switch is inserted with the shaft in the closed position, the shutter may be forced open and live parts may be contacted, resulting in severe injury or death.

Operating Handle and Door Interlock

A mechanical interlock prevents opening the medium voltage door with the switch in the closed position. A steel plunger lowers into position as the switch is closed. This plunger engages a bracket welded to the back of door, preventing the door from opening with the switch closed. In the unlikely event the switch malfunctions and cannot be opened, it will be necessary to drill out the welds to allow access to the medium voltage compartment. Prior to performing this work, make sure that power is disconnected upstream. Refer to **Figure 40**. Use a 1/4-inch bit and drill out the two welds that can be seen just below the handle mechanism. After repairs are made to the switch mechanism, the door should be replaced with a new factory built part to ensure the restoration of the interlock feature.

Figure 40. Drill Location for Emergency Entrance to Cabinet



Rectifier Assembly

Inspect diode fuses after each relay initiated trip due to a current fault, since this is the most severe service to which they will be subjected. Check the fuse resistance, and compare with the value of a new fuse. A pop-up indicator on the visible end of the fuse provides a visual sign of an open fuse. If a fuse has blown due to a fault, Eaton recommends that all three fuses on that secondary be replaced. Ensure that the replacement fuses are of the same rating and mounting configuration as those originally supplied.

Inverter

No regular maintenance of the inverter is required.

Door Filters

Door filters are washable; they should be inspected regularly and cleaned when dirty. A clogged filter will reduce the cooling efficiency of the blowers and shorten the life of the drive.

Loosening the thumbscrew on the top of the filter frame and tilting the frame out will allow removal of the filter.

Blowers and Fans

Blowers on the roof of the drive are provided to exhaust hot air from the drive enclosure. Fans on the inverter heatsink are provided to cool the inverter IGBTs. The blades of the blowers and fans should be cleaned at intervals deemed necessary by routine inspection. The main contactor should be in the off position and the drive isolation switch opened before servicing the unit.

Blowers are constructed using bearings with "lifetime lubrication." The blower is maintenance free.

Fans and blowers are of the heavy-duty type with a Mean Time Between Failure (MTBF) rating of 50000 hours for long life and dependable service. Expected life could be shortened if excessive dirt or dust damages the bearings. Replacement parts are available from Eaton.

Recommended Spare Parts

Refer to the documentation shipped with the job to see the recommended spare parts for the particular model(s) on that job.

Table 18. Spare Parts

Quantity	Description
1	Master Interface Card
1	Slave Interface Card
1	Power Supply Card
1	Backplane Card
2	F/O Interface Card
1	Controller Interface Card
1	Controller
2	Voltage Sensor
3	Current Sensor
1	Blower-Rh45m
1	Blower-W2e250
3	Fuse, Rectifier
3	Diode-Dual Module
2	Control Fuse
4	CPT Fuse
3	Input Power Fuse

SC9000 EP Maintenance Schedule

CAUTION

Before starting work review appropriate ILs and Control Schematic to understand the safety issues.

WARNING

BEFORE WORKING INSIDE THE DRIVE, THE VARIABLE FREQUENCY DRIVE MUST BE STOPPED.

Every Month

Clean the air filter

- The air filter can be cleaned while the drive is running
- Loosen screw on the filter mounting bracket
- Remove filter from bracket
- Vacuum filter
- Install the filter back in the bracket
- Perform this on all doors with filters

Verify that the blowers are running properly

- Listen for abnormal sounds from the blowers
- Through the keypad, review the air flow monitoring points. If air flow sensors are connected, the values should be above 900 lfpm. If redundant blowers are installed, one set of blowers will be running at one time

Review fault history through the keypad.

Every Year

Stopping the Variable Frequency Drive (VFD)

- STOP drive with the normal control system or use keypad STOP command
- After the input contactor has opened on the drive, monitor the DC bus voltage, wait until < 50 Vdc is shown. This should take approximately 5 minutes
- Open the Isolation switch on the drive and lock it out
- Open the doors to the drive. Locate the yellow shorting stick and ensure metal end of stick is grounded
- Discharge both halves of DC bus utilizing grounding studs on the rectifier
- Use a tick tracer to verify that all sources of AC control power is off

Cleaning

- Clean all cabinets with a non-static vacuum cleaner to remove any dust and debris. Do not vacuum any electronic boards or devices. Do not use canned air as this can leave a conductive film on material. Do not use compressed air as this can force particles further into the transformer

Inspect power components for signs of damage or heat stress.

Visually inspect all accessible wiring, check connections to verify snug fit, if found loose, tighten with a screw driver.

Control wiring

- Within the control bucket, check each wire is not loose
- All control wiring into low voltage controller and medium voltage controller should be properly shielded and grounded. Ensure a proper ground connection. DO NOT OVER TORQUE GROUNDING SCREWS ON SHIELD. This can crimp the wires within the shield and short them out
- Check pre-charge capacitor spade connector to ensure properly seated connection
- Validate pre-charge fuse resistance going to DC bus per schematic

24 Pulse Converter

- Remove Lexan barrier
- Check for any discoloration, overheating or mechanical stress
- Check power connections on the rectifier and power transformer by rotating the connections by hand. If a loose connection is found, the connection should be torqued. Torqueing of all power connections is not recommended
  - Cables from transformer labeled 1R, 1S, 1T, 2R, 2S, 2T, 3R, 3S, 3T, 4R, 4S and 4T
  - Semiconductor fast blowing fuse pins and connections F1 through F12
  - All bolted connections to the semiconductor fuses, diodes and cables
  - Dual diode pack module mounted on the heatsink
  - Positive, Negative, Neutral crimp and cable connections (POS, NEG, NEUT)
  - Voltage LEM sensor connections to the bus (POS, NEG, NEUT) and into the medium voltage controller MP1 and MP2
  - After drive has been stopped and bus is discharged, validate resistance across DC bus matches values as indicated by drawing set
  - When replacing Lexan barrier, make sure discharge studs are properly exposed to cutout and can be easily accessed

Blower and fans

- Check main and redundant blowers (redundant if applicable)
- Check secondary 480V blower fuse by resistance across terminals of each fuse
- Check each set of blower overload relays. Overload settings to be 3.2A with automatic reset
- Verify that all control wiring is properly seated and not loose
- Spin fans on Frame A for smooth turning and healthy bearings. Other frame sizes have fans facing sideways. Access and visual check to these fans may be difficult without removal of inverter and is not recommended if inverter is healthy
- Check removable air filter in front of drive for excess debris and particles. Clean off with warm water, dry off before reinstalling filters
- When drive is ready to be turned on, go to parameters P1.12.32.7 through P1.12.32.10
- Choose Force On or Force Off depending on the set being checked
- Visually inspect proper rotation of blowers and fans
- Audibly check that there is no excessive noise due to vibration in cabinets or in blower assembly

Contactor and fuse assembly visual inspection

- Remove the contactor
- Check that the phase barriers are in good condition and fit correctly. If broken or missing get new ones. The contactor will not have the Basic Impulse Level (BIL) without the barriers
- Inspect all bolted joints for signs of overheating and discoloration. Do not tighten with a wrench. If there are signs of overheating, take the joint apart and clean before reassembling
- Inspect fuses for signs of overheating, discoloration and mechanical damage
- Inspect all bolted joints, look for signs of overheating. Do not tighten to check
- Check line and load finger cluster springs. The tension should be about equal on all clusters. If springs are discolored or burned—replace. If finger clusters are burned on the contact surface—replace
- Mechanical Interlock: Inspect for free movement and alignment
- Check all wiring to see if it is secure in its terminal and tighten as required
- Check the operation of the auxiliary interlocks, pin 2-3, 4-5, 6-7 and 8-9 interlocks. Refer to the order drawings for special contact configuration. Standard arrangement is 2-3 and 6-7 being N.O. and 4-5 and 8-9 being N.C.
- Check pole closing—all at the same time. Two or three light or voltmeter method is OK
- Inspect hardware securing operation plate and moving armature to the main shaft
- Inspect operating lever mechanical interlock bracket on main shaft for any cracks or breaks
- Clean the contactor
  - Dry dirt and dust may be removed by blowing off with the output of a vacuum cleaner with a non-static tip
  - Grease and dirt film may be removed by wiping with "409' cleaner, then wipe with clean water or alcohol
  - Clean carefully the front of the contactor. Do not bang or bump the interlock activators, clean gently

Isolation switch

- Remove isolation switch (if necessary)
- Inspect isolation switch line fingers. Look for discoloration and overheating
- Check all bolts and screws for tightness. Check line finger spring
- Check that ground fingers and ground bars are OK
- Clean and re-grease line fingers with DC-4 silicone grease
- Check for smooth operation of handle
- Check operation of isolation switch auxiliary interlock. Switch must change position with first 15 degrees of opening movement of the switch handle
- Check all Kirk key interlocks. Interlock scheme on outline drawings
- Cell Inspection–Visual–Tight Connections–Overheating
  - Load cables and stabs
    Load cables
    Load stab assembly. Look for wear and burns
    Clean and lubricate with DC-4 silicone grease
  - Line stab assembly
    Remove shutter mechanism from isolation switch incoming line stab assembly
    Check for tight connection and any abnormal discoloration. Clean and re-grease stabs with DC-4 silicone grease
    Replace barrier
    Check operation of barrier for smooth operation
  - Cable entry and or exit locations
    Check cable entry ONLY if upstream power is disconnected feeding the drive, locked and tagged out
    Cable exit connection either in inverter section or incoming section of a stand-alone drive

Every 5 Years

Stopping the Variable Frequency Drive (VFD)

- STOP drive with the normal control system or use keypad STOP command
- After the input contactor has opened on the drive, monitor the DC bus voltage, wait until <50 Vdc is shown. This should take approximately 5 minutes
- Open the Isolation switch on the drive and lock it out
- Open the doors to the drive. Locate the yellow shorting stick and ensure metal end of stick is grounded
- Discharge both halves of DC bus utilizing grounding studs on the rectifier
- Use a tick tracer to verify that all sources of AC control power is off

Remove inverter from the cabinet and inspect stab connections and power wires. If the rear of the unit is accessible, the inverter does not need to be removed but the back sheet can be opened for this inspection.

Contactor and fuse assembly

- Replace control and power fuses
- Check the wear on vacuum bottles and high pot the bottles. Refer to Instruction Book IB48018N for further details on the operation and maintenance of the vacuum contactors

Replace fans and blower motors. These devices have a 50,000 hour life.

If the feeder to the drive lineup is locked out, the main bus compartment covers can be removed so that the power connections can be inspected. With the covers removed inspect the surge arresters and clean the compartments with a non-static vacuum cleaner.

Instructions for the Replacement of Medium Voltage Drive Classic Inverters

Scope

These are general instructions that apply to Frames A through E inverters of Eaton Medium Voltage Adjustable Frequency Drives.

Precautions

Due to the nature of the components used within the inverter, special precautions must be taken to avoid damage to the circuitry. The person working on the equipment must wear a grounded static strap thus eliminating the static charge on that person.

Use caution to prevent pinched fingers; inverters can weigh up to 2000 lbs (910 kg).

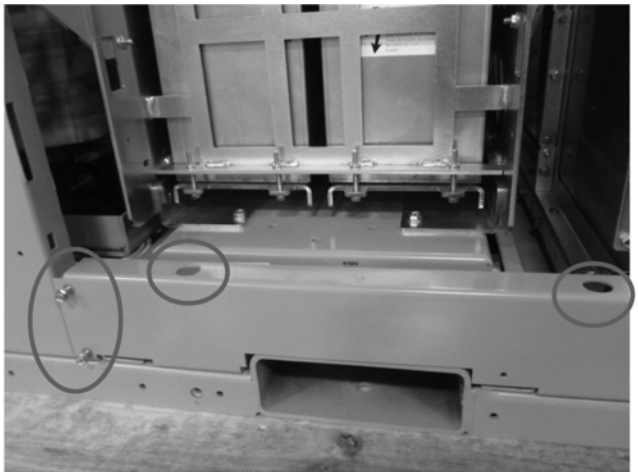
There is a hazard of electric shock whenever working on or near electrical equipment. Turn off all power supplying the equipment before starting work. Lock out the disconnecting means in accordance with NFPA 70E, "Electrical Safety Requirements for Employee Safety In the Workplace." Discharge rectifier, inverter, and DC bus with grounding stick. Where it is not feasible to de-energize the system, take the following precautions:

- Instruct persons working near exposed parts that are or may be energized to use practices (including appropriate apparel, equipment and tools) in accordance with NFPA 70E
- Require persons working on exposed parts that are or may be energized to be qualified persons who have been trained to work on energized circuits

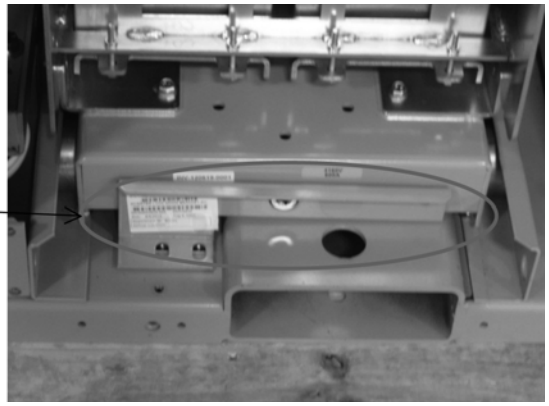
For the purpose of these instructions, a qualified person is one who is familiar with the installation, construction, or operation of the equipment and the hazards involved. In addition, this person should have the following qualifications:

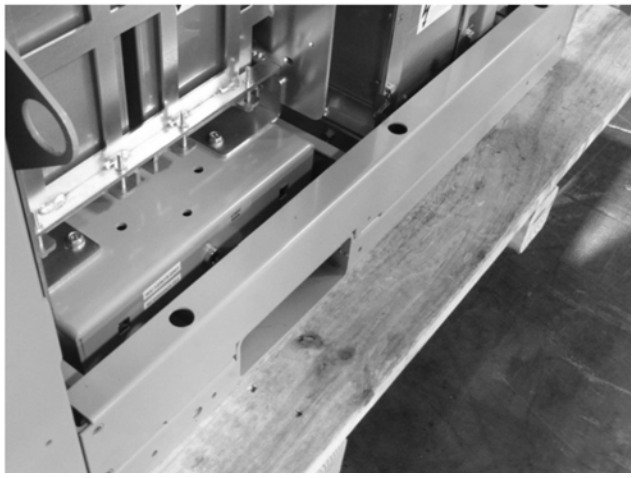
- Be trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices
- Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc. in accordance with established practices
- Be trained in rendering first aid
- Be knowledgeable with respect to electrical installation codes and standards, for example, the National Electrical Code (NEC)

1. Remove tubing cover plate (not shown).
2. Detach the channel located at the bottom front of the inverter by removing bolts as shown below. Save all hardware.

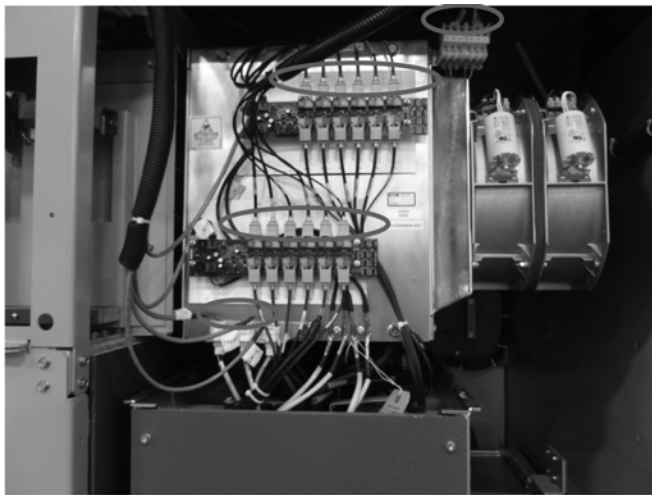


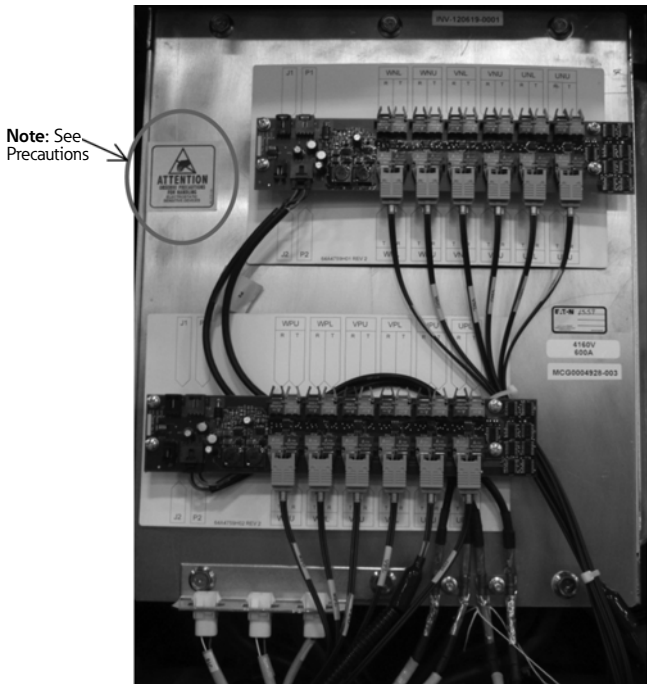
3. Detach the inverter shipping bracket by removing four fasteners.





4. Disconnect the fiber optic and power cables running to the control rack and place them in safe locations where they cannot be run over by mobile equipment or snagged on inverter radiator.

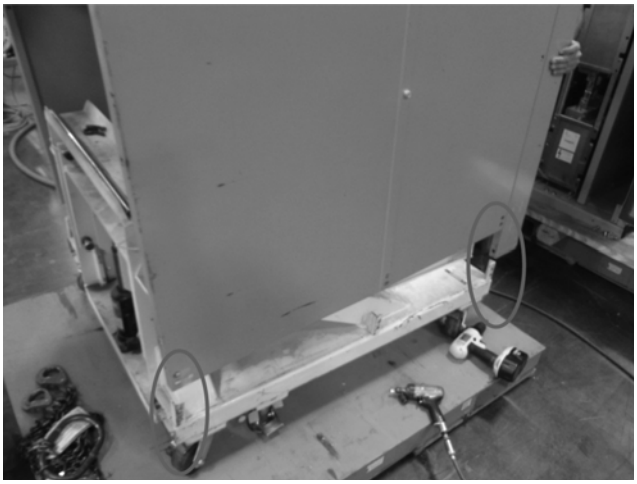




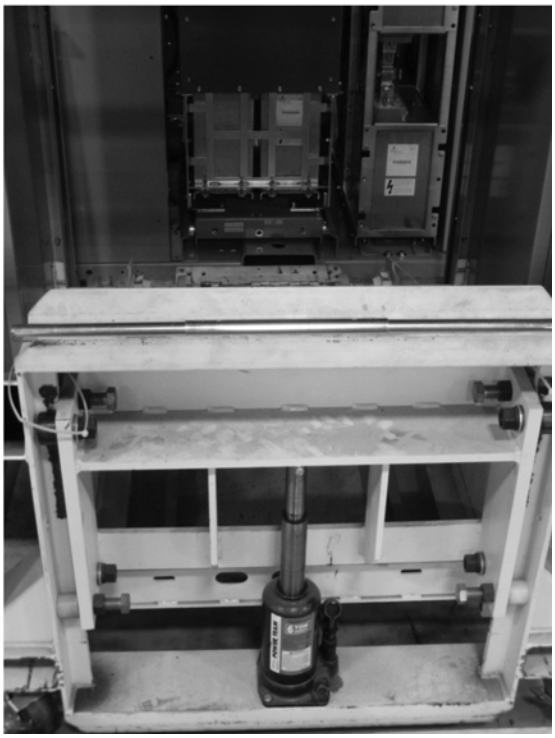
5. Detach the channel located at the middle front of the inverter by removing the bolts as shown below. Save all hardware.

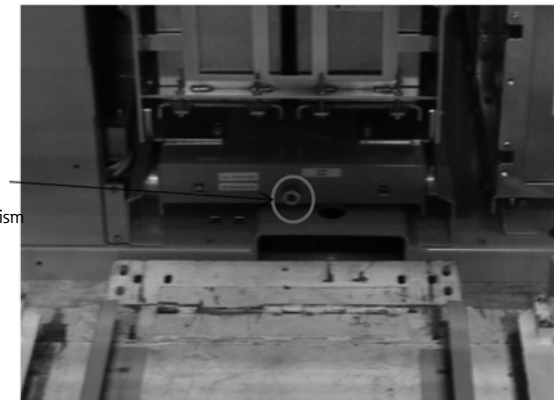
6. Take out the spare parts stored inside the lifting cart provided by Eaton and put them in a safe place to avoid breakage or accidents.

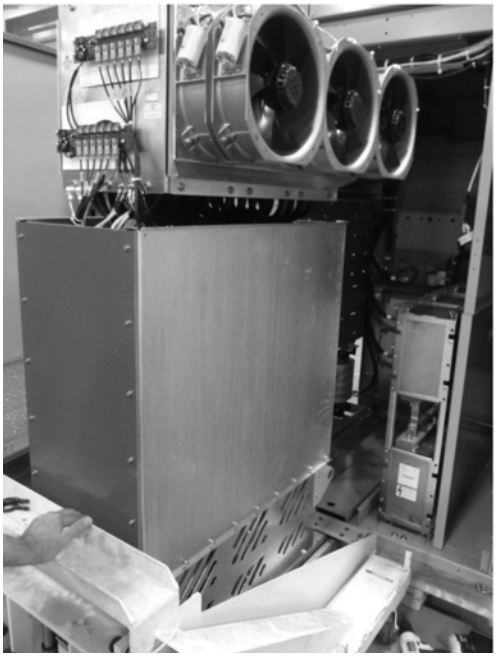
7. Detach the surrounding structure of the lifting cart by removing the bolts as shown below and raising it by means of an overhead crane. If an overhead crane is not available, detach the top cover only by removing the respective bolts in order to make room for the inverter.

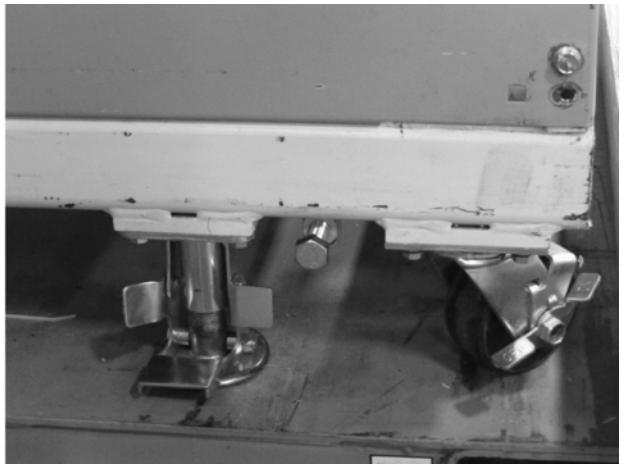


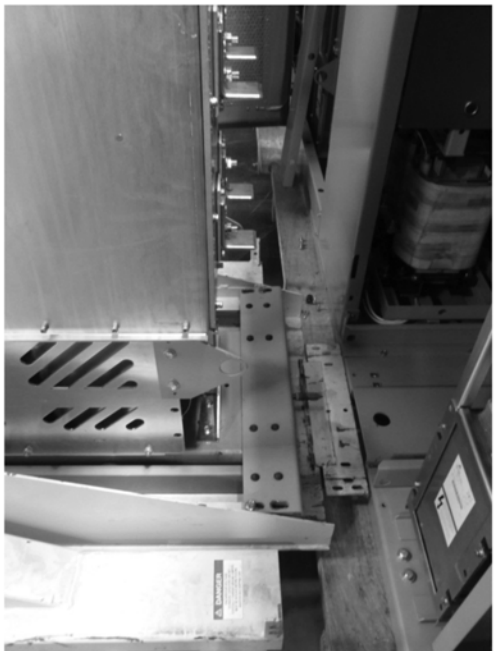
8. Jack the lifting cart up until it reaches the same level as the rolling base of the inverter. Place the lifting cart in front of the rolling base of the inverter and pull down the safety pedestals in order to lock the cart in place.





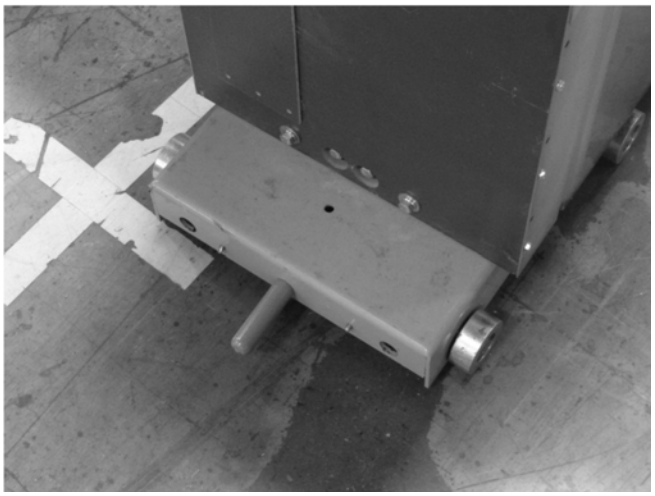






9. Loosen the inverter racking mechanism (threaded rod). Roll the inverter forward until the front wheels meet the end of the rail, and install a channel on the opposite side to prevent the inverter from slipping and falling when the cart is moving.

10. Cover the end of the threaded rod with a safety protector.



Instructions for the Installation of Medium Voltage Drive Power Pole Inverters

Scope

These are general instructions that apply to Frames D and E Power Pole inverters of Eaton SC9000 EP Medium Voltage Adjustable Frequency Drives.

Precautions

Due to the nature of the components used within the inverter, special precautions must be taken to avoid damage to the circuitry. The person working on the equipment must wear a grounded static strap thus eliminating the static charge on that person.

Use caution to prevent pinched fingers; inverters can weigh up to 2000 lbs (910 kg).

There is a hazard of electric shock whenever working on or near electrical equipment. Turn off all power supplying the equipment before starting work. Lock out the disconnecting means in accordance with NFPA 70E, "Electrical Safety Requirements for Employee Safety In the Workplace." Discharge rectifier, inverter, and DC bus with grounding stick. Where it is not feasible to de-energize the system, take the following precautions:

1. Instruct persons working near exposed parts that are or may be energized to use practices (including appropriate apparel, equipment and tools) in accordance with NFPA 70E.
2. Require persons working on exposed parts that are or may be energized to be qualified persons who have been trained to work on energized circuits.

For the purpose of these instructions, a qualified person is one who is familiar with the installation, construction, or operation of the equipment and the hazards involved. In addition, this person should have the following qualifications:

1. Be trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.
2. Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc. in accordance with established practices.
3. Be trained in rendering first aid.
4. Be knowledgeable with respect to electrical installation codes and standards, for example, the National Electrical Code (NEC).

Preparation

Before installation, ensure that the structure has been properly prepared during assembly or removal of a previously installed inverter. This is a good time to check torqued connections and remove any debris.

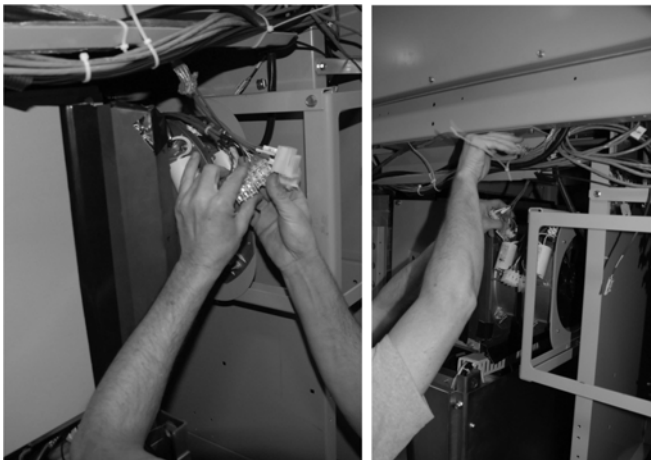
1. Align inverter wheels with guide rails and adjust cart to proper height for a smooth transition.

2. Ensure that all wiring is held or secured free from interference with the inverter. Take special care of the position of the fiber optic cables which can catch on the heat pipe radiators.
3. Push the inverter forward slowly until the rear racking mechanism and stabs reach the stab panel.

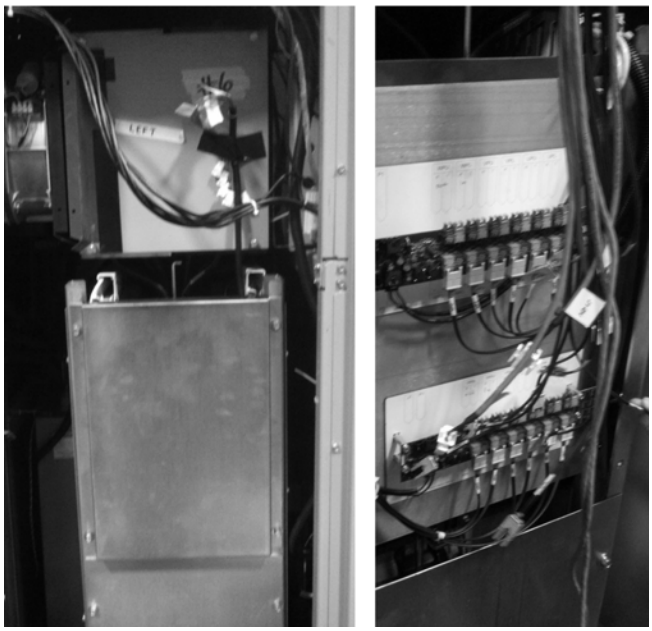
4. Using a 3/8-inch socket, remove the upper panels on the rear of the inverter section. Doing so allows for a clear view of the stabs to verify a proper connection.

5. Using a 3/8-inch drive tool, turn the racking mechanism screw clockwise until the inverter stabs are fully engaged with the stab panel fingers as shown. Verify from the rear of the enclosure that a proper stab alignment was achieved.

6. Install the side flange of the formex fan shroud and reconnect the fan wiring terminal blocks.



7. Remove the metal cover from the front of the inverter and connect the ground cables, fiber optics, power supplies and RTD wiring per the applicable schematics. Reinstall the cover insuring that no wires are pinched.

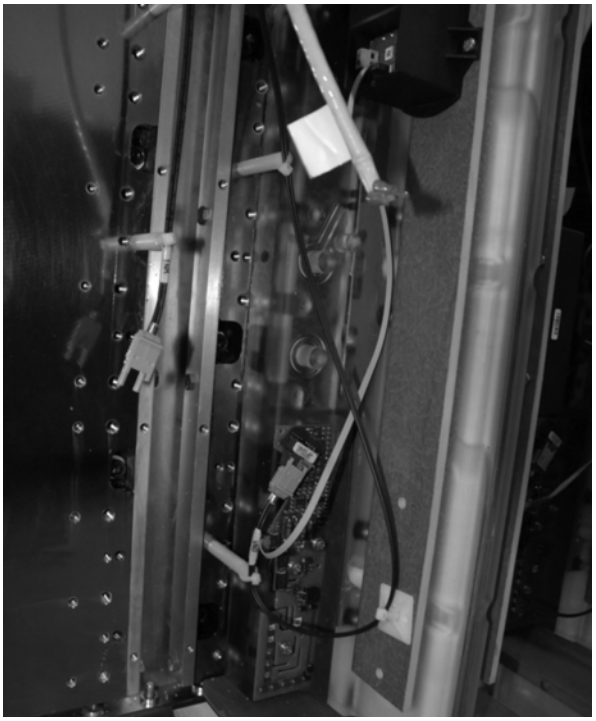


8. Check for loose wires, tools or hardware and reinstall all covers.

The Inverter is retrofitable into the Frame B–E Medium Voltage Drives with minimal replacement and addition of parts. The rear stab panel has to be replaced and fan mountings for the isolated fans used with the new Power Pole Inverter have to be installed. The removal and/or bracing of auxiliary capacitors may also be necessary.

The Power Poles themselves are removable and replaceable within the rollout Inverter with very little difficulty and time. After removing the Inverter side sheet, remove the outer pole cover from the old pole needing replacement. The old pole is then unbolted from the capacitor, AC bus, and heatsink after all fiber optic and power cables have been disconnected. After removal of the old pole the heatsink is cleaned of thermal paste using mineral spirits and/or denatured alcohol. A new layer of thermal paste is reapplied to the heatsink using screen. Using two mounting studs, the new Power Pole is positioned into place and the M6 caphead screws are started into the mounting holes to secure the pole to the heatsink. The AC bus connection and capacitor terminal connections are then connected before anything is tightened down. The M6 screws mounted to the heatsink shall be torqued to 2 Nm. After waiting 30 minutes they are further torqued to 5 Nm. The AC bus connections are to be torqued to 5 Nm and the capacitor connection to 10 Nm. The fiber optic and power supply cables are reconnected and the outer pole cover replaced. Static straps required.

Figure 41. Disconnect Power Supply, Fiber Optic and Ribbon Cables



(Care must be taken with ribbon connector. Use tip of pen to push on red release button on ribbon connector before applying any force.)

Figure 42. Remove Bolts to Capacitor

Figure 43. Unbolt Electrical Connections at Back and Bottom

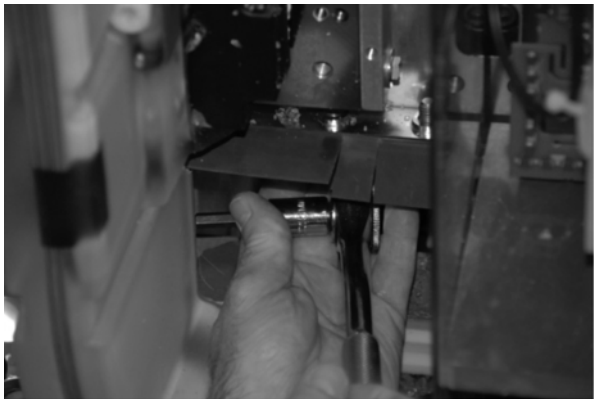


Figure 44. Fix Screen to Heatpipe

Figure 45. Apply Thermal Paste

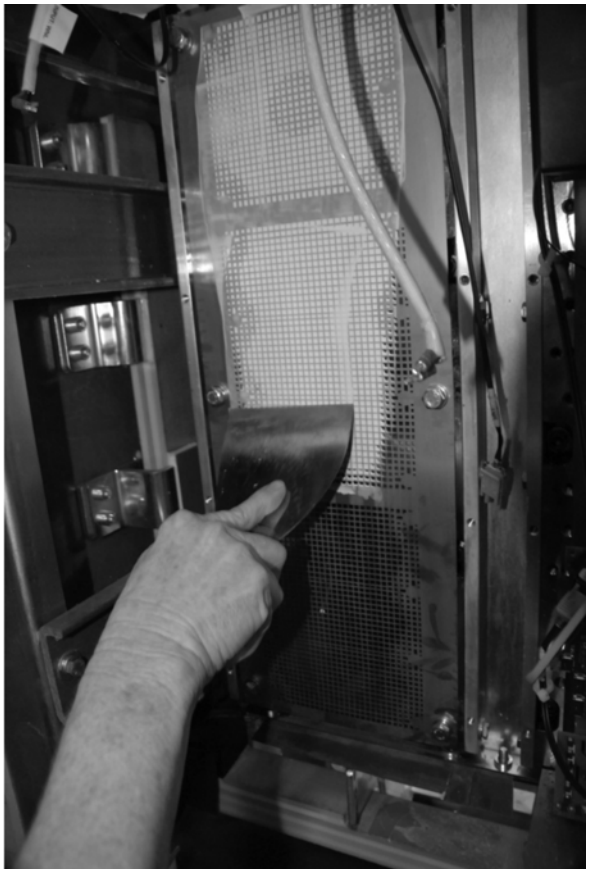


Figure 46. Remove Screen Carefully

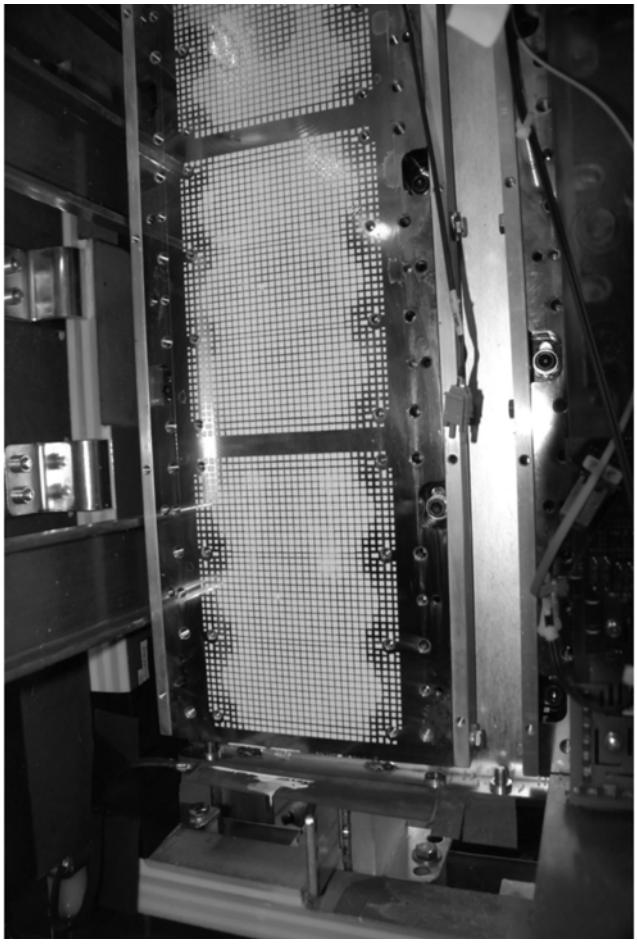


Figure 47. Install Tapered Pins for Aligning Power Pole

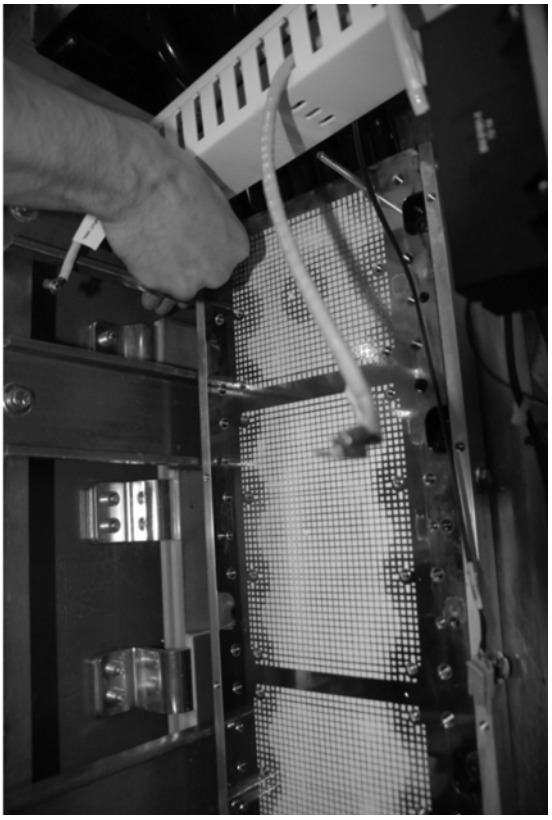


Figure 48. Place Power Pole on Heatpipe

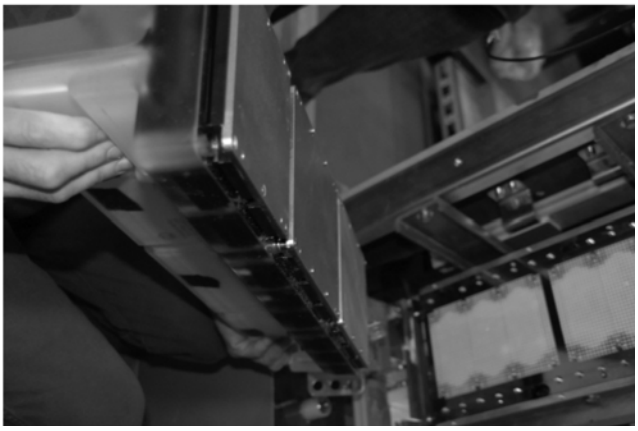


Figure 49. Secure Hardware to Power Pole (Wait 30 Minutes and Torque Appropriately)

Figure 50. Secure Electrical Connections

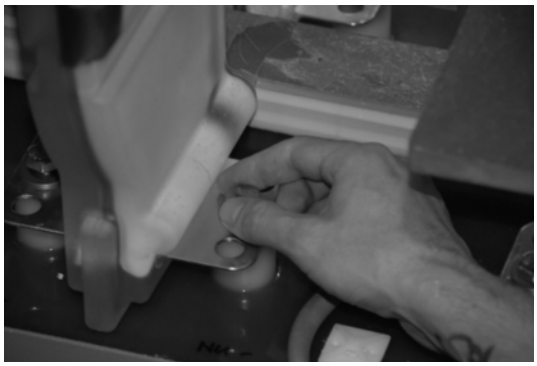
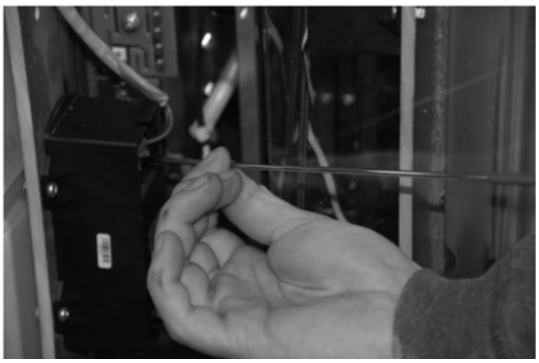


Figure 51. Mount Paddles with Power Supplies and Gate Drivers (IMPORTANT: Remove Bonding and Use Static Precautions)

Figure 52. Reconnect Power Supplies and Fiber Optic Cables



Replace covers and reinstall inverter.

Chapter 9: Troubleshooting and Fault Tracing

Powering-Off Procedure

Before performing any task during which you must inspect, maintain, or troubleshoot the SC9000 EP power system, you must do the following:

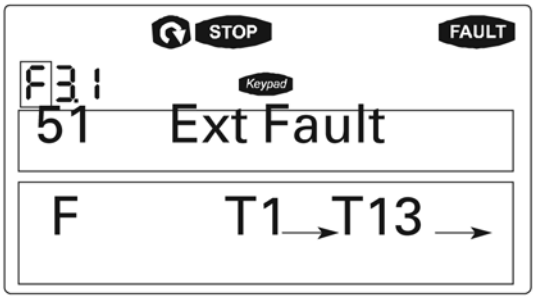
1. Stop SC9000 EP and observe that the motor has completely stopped.
2. If control power is ON, make sure the DC bus voltage is at a safe level (wait until < 50 Vdc is shown) by means of a computer or the keypad.
3. Turn OFF the incoming power to the drive by opening and grounding the disconnect switch for the circuit that feeds the drive. Follow all applicable lockout/tagout procedures.
4. Turn OFF the control power. If control power is needed, plug an extension cord from any 120 V power source into the test plug located on the control panel. This will give 120 V control power to the unit.
5. Wait for at least 5 minutes before proceeding to the next step.
6. Open the doors to the drive. Locate the yellow shorting stick and ensure metal end of stick is grounded.
7. Discharge both halves of DC bus utilizing grounding studs on the rectifier.
8. Proceed with the necessary inspection, troubleshooting, or maintenance.

Indications

When a fault other than an ALARM takes place, the SC9000 EP stops. The sequence indication F1, the fault code, a short description of the fault and the fault type symbol will appear on the display located on the control panel. In addition, the indication FAULT or ALARM is displayed and, in case of a FAULT, the red LED on the keypad starts to blink. If several faults occur simultaneously, the sequence of active faults (accessible from menu M3) can be browsed with the Browser buttons. See **Figure 53**.

The active faults memory can store a maximum of 10 faults in the sequential order of appearance, with F1 the most recent fault and F10 the oldest. The fault remains active until it is cleared with either the STOP or RESET buttons or with a reset signal from the I/O terminal. Upon fault reset, the display will be cleared and will return to the same state it was before the fault trip. If the fault is still present and no remedial actions have been taken, the drive will not power on, even if the buttons STOP or RESET are pressed.

Figure 53. Active Fault Display Example



CAUTION

Remove any external start signals or permissives before resetting the fault to prevent an unintentional restart of the SC9000 EP, which could result in personal injury or equipment damage.

Fault Type Range: A, F, AR, FT
Fault Type
There are four different types of faults. These faults and their definitions are given in **Table 19**.

Note: These fault codes represent those in version 4.12 of the firmware. For information on fault codes for prior or subsequent versions, contact the factory.

Table 19. SC9000 EP/SPX Controller Fault Codes

Fault Code	Item	Description
1	Overcurrent	Current has reached four times the maximum rated FLA
2	Overvoltage	Voltage on DC bus has reached high trip threshold (nominal 118% rated RMS)
3	Groundfault	Ground fault trip
7	Saturation	IGBT saturated
9	Undervoltage	Voltage on DC bus has gone below low voltage trip threshold (nominal 60% rated RMS)
10	Input Phase	Open phase at drive input
11	Output Phase	Open phase at drive outputs
13	Undertemp	IGBTs are below minimum temperature
14	Overtemp	Temperature of heatsink above maximum value
15	Motor Stall	Motor has stalled
16	Motor Overtemp	Calculated motor temp based on I^2T to high
17	Motor UnderLoad	Motor torque below minimum threshold
22	ParameterFault	A parameter value has been corrupted
24	CounterFault	A counter value has been corrupted
29	Thermister	Thermister fault (requires that thermister board be installed)
31	IGBT Temp	IGBT temp. Calculated temp of IGBT to high
41	IGBT Temp	IGBT temp. Calculated temp of IGBT to high
50	AnalogIn<4ma	Analog input link is below min of 4 mA
51	External Fault	External fault input tripped
52	Keypad Comm	Keypad communications lost
53	FieldBus Comm	Fieldbus communications lost
54	Slot Comm	Adapter board in slot communication fault
55	Reserved	—
56	ResHeatSink	Discharge resistor heat sink temperature is too high
57	Identification	Motor identification run failed
58	RunEnableLost	Run enable DIN lost (dropped after running)
59	BypassContactorClosed	Run disabled due to bypass contactor closed
60	SineFilterCapOverTemp	Sine filter cap snap switch (overtemperature)
61	SineFilterCapOverPressure	Sine filter cap snap switch (overpressure)
62	ExciterFieldLoss	Feedback from 'exciter OK' input lost
63	SineFilterAirFlow	Sine filter fan flow low
64	Rectifier OverTemperature	Rectifier heatsink too hot
65	Inverter OverTemperature	Inverter heatsink too hot
66	Reactor OT	External inductor overtemperature
67	SyncFail	Unable to sync drive output to grid
68	SyncLost	Drive output to grid sync lost before sync transfer completed
70	AirFlow	Blower airflow is low
71	LineVoltLoss	Three phase medium voltage to drive lost a 24xx relay
72	E-Stop	Emergency stop pulled
73	IsoSwitchOpen	Main power isolation switch is open
74	XfmrOT F/L	Transformer left coil overtemperature
75	XfmrOT Middle	Transformer middle coil overtemperature
76	XfmrOT R/F	Transformer right coil overtemperature
77	XfmrOT Core	Transformer core overtemperature
78	Hi Ambient	Ambient air temperature is too high
79	CheckFilter	Possible filter clogged, temperature difference between inlet and exhaust is high
80	ExhaustHot	Output air temperature at blower is too high
81	MasterBoard	Failure in master board or MITG
82	SlaveBoard1	Failure in slave1 board or SITG1
83	SlaveBoard2	Failure in slave2 board or SITG2
84	SlaveBoard3	Failure in slave3 board or SITG3
85	DCVoltageSensor	Problem with sensor used to read DC bus
86	Precharge	Problem with precharge circuit
87	MainBlower	Main blower flow low
88	RedunBlower	Redundant blower flow low
89	BlowerLoss	Blower failure
90	OutputOpen	Output contactor is open when expected closed, or closed when expected open
91	CAN Master	Failure in CAN communications to Master or MITG
92	CAN Slave1	Failure in CAN communications to Slave1 or SITG1
93	CAN Slave2	Failure in CAN communications to Slave2 or SITG2
94	CAN Slave3	Failure in CAN communications to Slave3 or SITG3
95	Memory	Memory failure in NXP controller
96	Turck	Problem with Turck I/O controller or comms to Turck bus coupler
97	MotorVoltage	Motor voltage out of band
98	MainOpened	Main contactor is open when expected closed
99	ExcFldOutband	External exciter source field is out of band

Fault Code Range: 1–99
Fault codes indicate the cause of the fault. See **Table 19** for further explanation.

Fault Time Range: T.1–T.13

Data Record In this menu, important data recorded at the time of the fault is available. This feature is intended to help the user or the service person to determine the cause of fault. **Table 20** indicates the information that is recorded.

Table 20. Fault Time Data

Data	Units	Description
T.1	D	Counted Operation Days (Fault 43: Additional Code)
T.2	hh:mm:ss (d)	Counted Operation Hours (Fault 43: Counted Operational Days)
T.3	Hz hh:mm:ss	Output Frequency (Fault 43: Counted Operational Hours)
T.4	A	Motor Current
T.5	V	Motor Voltage
T.6	%	Motor Power
T.7	%	Motor Torque
T.8	V	DC Bus Voltage
T.9	°C	Unit Temperature
T.10	—	Ruin Status
T.11	—	Direction
T.12	—	Warnings
T.13	—	Zero Speed

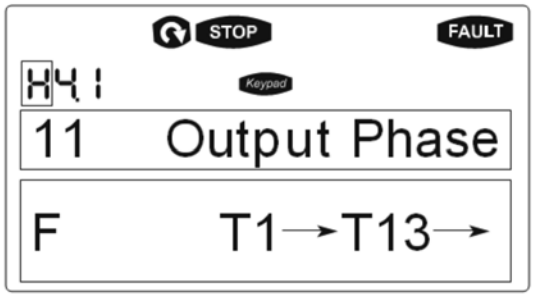
Note

① Real time record. If read time is set, T.1 and T.2 will appear as follows:

T.1	yyyy-mm-dd	Counted Operation Days (Fault 43: Additional Code)
T.2	hh:mm:ss.sss	Counted Operation Hours (Fault 43: Counted Operation Days)

The SC9000 EP's memory can store a maximum of 30 faults (accessible from menu M4), in the order of appearance. If there are 30 uncleared faults in the memory, the next occurring fault will erase the oldest fault from the memory. Pressing the ENTER button for 3 seconds will clear the entire fault history.

Figure 54. Sample Fault History Display



If fault codes such as 81 or 84, in conjunction with their inherent description (Master Board and/or Slave Board), are shown on the display located on the control panel, an additional step has to be performed. Examine the Master interface LED indication and the Slave interface LED indication. These will be two digit numeric codes that together give more detailed information about the fault. See **Tables 21** and **22** for the correlation between the numbers and the specific faults.

Record this information for future reference.

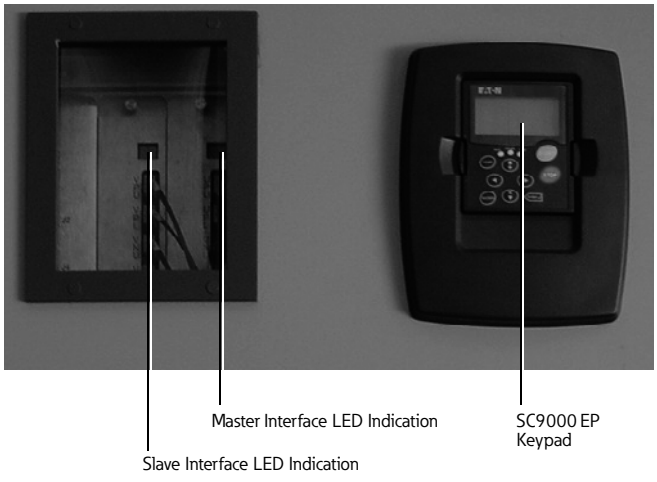
If there is an active fault of this type, the drive will rapidly flash one of the error codes from the **Tables 19** and **20**. Hitting reset will attempt to reset the drive as usual. If the fault is still present, the rack will not reset. If the fault has been cleared, the rack will reset and the LED display will no longer rapidly blink.

If there was a fault but it is no longer active the LED displays will slowly cycle between the fault codes. The previous 10 faults will be cycled through. Pressing STOP and RESET buttons clears the LED display.

If there are no faults of this type in the fault log it will display 00.

The drive LED displays will alternate flashing "66" and "99" when the drive is running.

Figure 55. LED Indications



Note: These fault codes represent those in version 4.12 of the firmware. For information on fault codes for prior or subsequent versions, contact the factory.

Table 21. MIC/SIC Fault Codes (V1.6)

Fault Code 7 Seg Display	Item	Description
1	INVERTER1_W_OT_FAULT	Inverter1 pole W over temperature fault
2	CPLD_VPU_DS_FAULT	Desaturation fault VPU Gate
3	CPLD_WNU_FO_FAULT	Fiber optic fault WNU Gate
4	CPD_VPU_FO_FAULT	Fiber optic fault VPU Gate
5	INVERTER2_U_OT_FAULT	Inverter1 pole U over temperature fault
6	—	—
7	—	—
8	—	—
9	—	—
10	—	Illegal opcode fault
11	—	NA
12	CPLD_VPL_DS_FAULT	Desaturation fault VPL Gate
13	CPLD_WNL_FO_FAULT	Fiber optic fault WNL Gate
14	CPD_VPL_FO_FAULT	Fiber optic fault VPL Gate
15	INVERTER2_V_OT_FAULT	Inverter2 pole V over temperature fault
16	—	—
17	—	—
18	—	—
19	—	—
20	—	—
21	—	Ambient temperature fault
22	CPLD_VNU_DS_FAULT	Desaturation fault VNU Gate
23	CPLD_UPU_DS_FAULT	Desaturation fault UPU Gate
24	CPLD_WPU_FO_FAULT	Fiber optic fault WPU Gate
25	INVERTER2_W_OT_FAULT	Inverter2 pole W over temperature fault
26	—	—
27	—	—
28	—	—
29	—	—
30	—	Read only memory checksum fail
31	—	Motor Overtemperature
32	CPLD_VNL_DS_FAULT	Desaturation fault VNL Gate
33	CPLD_UPL_DS_FAULT	Desaturation fault UPL Gate
34	CPLD_WPL_FO_FAULT	Fiber optic fault WPL Gate
35	—	Inverter X over temperature fault
36	—	—
37	—	—
38	—	—
39	—	—

Table 21. MIC/SIC Fault Codes (V1.6), Continued

Fault Code 7 Seg Display	Item	Description
40	—	Random access memory checksum fail
41	DCBalLow	DC bus is unbalanced because one side of bus is low.
42	CPLD_WNU_DS_FAULT	Desaturation fault WNU Gate
43	CPLD_UNU_DS_FAULT	Desaturation fault UNU Gate
44	CPLD_NEXT_CARD_NOT_READY	Next card not ready
45	—	Motor B Overtemperature
46	—	—
47	—	—
48	—	—
49	—	—
50	—	Computer operating properly fault.
51	DCBalHIgh	DC bus is unbalanced because one side of bus is high
52	CPLD_WNL_DS_FAULT	Desaturation fault WNL Gate
53	CPLD_UNL_DS_FAULT	Desaturation fault UNL Gate
54	CPLD_NEXT_CARD_FAULT	Fault detected on other card
55	—	—
56	—	—
57	—	—
58	—	—
59	—	—
60	—	Computer operating properly fault.
61	DCUnderVoltage	One or both sides of DC bus voltage is too low to operate
62	CPD_UNU_FO_FAULT	Fiber optic fault UNU Gate
63	CPLD_WPU_DS_FAULT	Desaturation fault WPU Gate
64	MAIN_CONTACTOR_SHORT_FAULT	Main contactor drive FET shorted
65	—	—
66	—	—
67	—	—
68	—	—
69 -	—	—
70	—	A/D converter failure
71	MOTOR_OVER_CURRENT_FAULT	Overcurrent
72	CPL_UNL_FO_FAULT	Fiber optic fault UNL Gate
73	CPLD_WPL_DS_FAULT	Desaturation fault WPL Gate
74	PRE_CHARGE_CONTACTOR_SHORT_FAULT	Precharge contactor drive FET shorted
75	—	—
76	—	—
77	—	—
78	—	—
79	—	—
80	INVERTER1_U_OT_FAULT	Inverter1 pole U over temperature fault
81	DESATURATION_FAULT	General desaturation fault

Table 21. MIC/SIC Fault Codes (V1.6), Continued

Fault Code 7 Seg Display	Item	Description
82	CPLD_VNU_FO_FAULT	Fiber optic fault VNU Gate
83	CPLD_UPU_FO_FAULT	Fiber optic fault UPU Gate
84	DISCHARGE_CONTACTOR_SHORT_FAULT	Discharge contactor drive FET shorted
85	—	—
86	—	—
87	—	—
88	—	—
89	—	—
90	INVERTER1_V_OT_FAULT	Inverter1 pole V over temperature fault
91	CPLD_FAULT	General CPLD fault
92	CPLD_VNL_FO_FAULT	Fiber optic fault VNL Gate
93	CPLD_UPL_FO_FAULT	Fiber optic fault UPL Gate
94	BLOWER_RELAY_SHORT_FAULT	Blower contactor drive FET shorted
95	—	—
96	CAN_COMMUNICATION_TIMEOUT	CAN communications timeout
97	DSP_SYNCHRONISM_FLT	Digital signal processor fault
98	DCOvervoltage	One or both sides of DC bus voltage is too high to operate
99	DSP_SYNC_SIGNAL_FLT	Digital signal processor sync fault

Table 22. ITG Fault Codes (V2.0)

Fault Code	Item	Description
1	INVERTER1_W_OT_FAULT	
2		
3		
4	CPLD_UNU_FO_FAULT	
5	CPLD_OV_FAULT	Not Currently Used
6	CPLD_OCW_FAULT	
7	CPLD_VPU_ACK_FAULT	
8	CPLD_UPU_ACK_FAULT	
9		
10	ILLEGAL_OPCODE_FAULT	
11	RESERVED	
12		
13	CPLD_WNL_FO_FAULT	
14	CPLD_UNL_FO_FAULT	
15	CPLD_OV2_FAULT	Not Currently Used
16	CPLD_OCV_FAULT	
17	CPLD_VPL_ACK_FAULT	
18	CPLD_UPL_ACK_FAULT	
19		
20	ILLEGAL_INTERRUPT_FAULT	

Table 22. ITG Fault Codes (V2.0), Continued

Fault Code	Item	Description
21	MOTOR_A_OT_FAULT	Ambient (Backplane)
22		
23	CPLD_UPU_DS_FAULT	Desat Fault on Phase
24	CPLD_WPU_FO_FAULT	
25	CPLD_OV3_FAULT	Over Voltage Upper DC Bus
26	CPLD_OCW_FAULT	
27	CPLD_VNU_ACK_FAULT	
28	CPLD_UNU_ACK_FAULT	
29		
30	ROM_CHECKSUM_FAULT	
31		
32		
33	CPLD_UPL_DS_FAULT	
34	CPLD_WPL_FO_FAULT	
35	CPLD_OV4_FAULT	Over Voltage Negative Bus
36	CPLD_EXT_FAULT	
37	CPLD_VNL_ACK_FAULT	
38	CPLD_UNL_ACK_FAULT	
39		
40	RAM_CHECKSUM_FAULT	
41	Reserved	NXP Monitors for Undervoltage
42		
43	CPLD_UNU_DS_FAULT	
44	CPLD_NEXT_CARD_NOT_READY	
45	MOTOR_A_OT_FAULT RTD 4	
46		
47	CPLD_WNU_ACK_FAULT	
48	CPLD_WPU_ACK_FAULT	
49		
50	COP_FAULT	
51	Positive DC Bus Unbalance	DC BUS Voltage Upper Bus Unbalanced
52		
53		
54	CPLD_NEXT_CARD_FAULT	
55		
56		
57	CPLD_WNL_ACK_FAULT	
58	CPLD_WPL_ACK_FAULT	
59		
60	COP_CLOCK_FAULT	
61	Negative DC Bus Unbalance	DC BUS Voltage Lower Bus Unbalanced
62	VPU FO Fault	

Table 22. ITG Fault Codes (V2.0), Continued

Fault Code	Item	Description
63	CPLD_WPU_DS_FAULT	
64	RESERVED	NXP Monitors Feedback
65		
65		
66		
67		
68		
69		
70	A_TO_D_FAULT	
71	MOTOR_OVER_CURRENT_FAULT	
72	VPL FO Fault	
73	CPLD_WPL_DS_FAULT	
74	RESERVED	NXP Monitors Bus
75		
76		
77		
78		
79		
80	INVERTER1_U_OT_FAULT	
81	DESATURATION_FAULT	
82	CPLD_VNU_FO_FAULT	
83	CPLD_UPU_FO_FAULT	
84	RESERVED	
85		
86		
87		
88		
89		
90	INVERTER1_V_OT_FAULT	
91	CPLD_FAULT	
92	CPLD_VNL_FO_FAULT	
93	CPLD_UPL_FO_FAULT	
94	RESERVED	
95		
96		
97	DSP_SYNCHRONISM_FLT	
98	Reserved	
99	DSP_SYNC_SIGNAL_FLT	

Notes

Desat = Desats detected while drive is running.
Ack = No ACK from inverter while drive is running.
FO = Detects loss of fiber feedback while drive is stopped.

Appendix A: Typical SC9000 EP Configurations

Table 23. SC9000 EP AFD Configuration Matrix

The SC9000 EP model number can be configured by using the table below. For options or requirements outside this table, please consult factory. The example below, SC 93C100-VT-E is a SC9000 EP, 4160V input, 4160V output, 1000 hp, VT, without Bypass.

SC9	3		C		100–						V		E		—	—
Series	Input Voltage		Output Voltage			2400V Output	3300V Output	4160V Output	6600V Output	6900V Output ①	Duty Rating		Style		Options	
Code	Code	Volt	Code	Volt	Code	hp	hp	hp	hp	hp	Code		Code			
SC9	1	2400, 60 Hz	A	2400	030	300	300	300	300	300	V	VT	E	No bypass	Consult factory	
	2	3300, 60 Hz	B	3300	035	350	350	350	350	350	C	CT ②	F	FVNR bypass	Consult factory	
	3	4160, 60 Hz	C	4160	040	400	400	400	400	400			G	RVAT bypass	Consult factory	
	4	4800, 60 Hz	D	4800	045	450	450	450	450	450			H	RVR bypass	Consult factory	
	5	6600, 60 Hz	E	6600	050	500	500	500	500	500			I	RVSS bypass	Consult factory	
	6	6900, 60 Hz	F	6900	060	600	600	600	600	600			J	FVR bypass		
	7	12,470, 60 Hz	G	12,470	070	700	700	700	700	700			K	RVATR bypass		
	8	13,200, 60 Hz	H	13,200	080	800	800	800	800	800			L	RVRR bypass		
	9	13,800, 60 Hz	I	13,800	090	900	900	900	900	900			M	RVSSR bypass		
	10	2400, 50 Hz			100	1000	1000	1000	1000	1000						
	11	3300, 50 Hz			125	1250	1250	1250	1250	1250						
	12	4160, 50 Hz			150	1500	1500	1500	1500	1500						
	13	4800, 50 Hz			175	1750	1750	1750	1750	1750						
	14	6000, 50 Hz			200	2000	2000	2000	2000	2000						
	15	6600, 50 Hz			225	2250	2250	2250	2250	2250						
	16	6900, 50 Hz			250	2500	2500	2500	2500	2500						
	17	10,000, 50 Hz			275		2750	2750	2750	2750						
	18	11,000, 50 Hz			300		3000	3000	3000	3000						
	19	12,000, 50 Hz			325		3250	3250	3250	3250						
					350		3500	3500	3500	3500						
					375		3750	3750	3750	3750						
					400		4000	4000	4000	4000						
					425			4250	4250	4250						
					450			4500	4500	4500						
					475			4750	4750	4750						
					500			5000	5000	5000						
					525			5250	5250	5250						
					550			5500	5500	5500						
					575			5750	5750	5750						
					600			6000	6000	6000						
					650			6500	6500	6500						
					700			7000	7000	7000						
					750			7500	7500	7500						
					800			8000	8000	8000						
					850			8500	8500	8500						
					900			9000	9000	9000						
					950			9500	9500	9500						
					1000			10,000	10,000	10,000						
					1200			12,000	12,000	12,000						

Notes

① Consult factory.

② For CT applications, consult factory.

VT = Variable torque 110% for 1 minute.
Shaded area indicates no availability at this time.

Figure 56. Typical Schematic for SC9000 EP AFD—Sheet 1

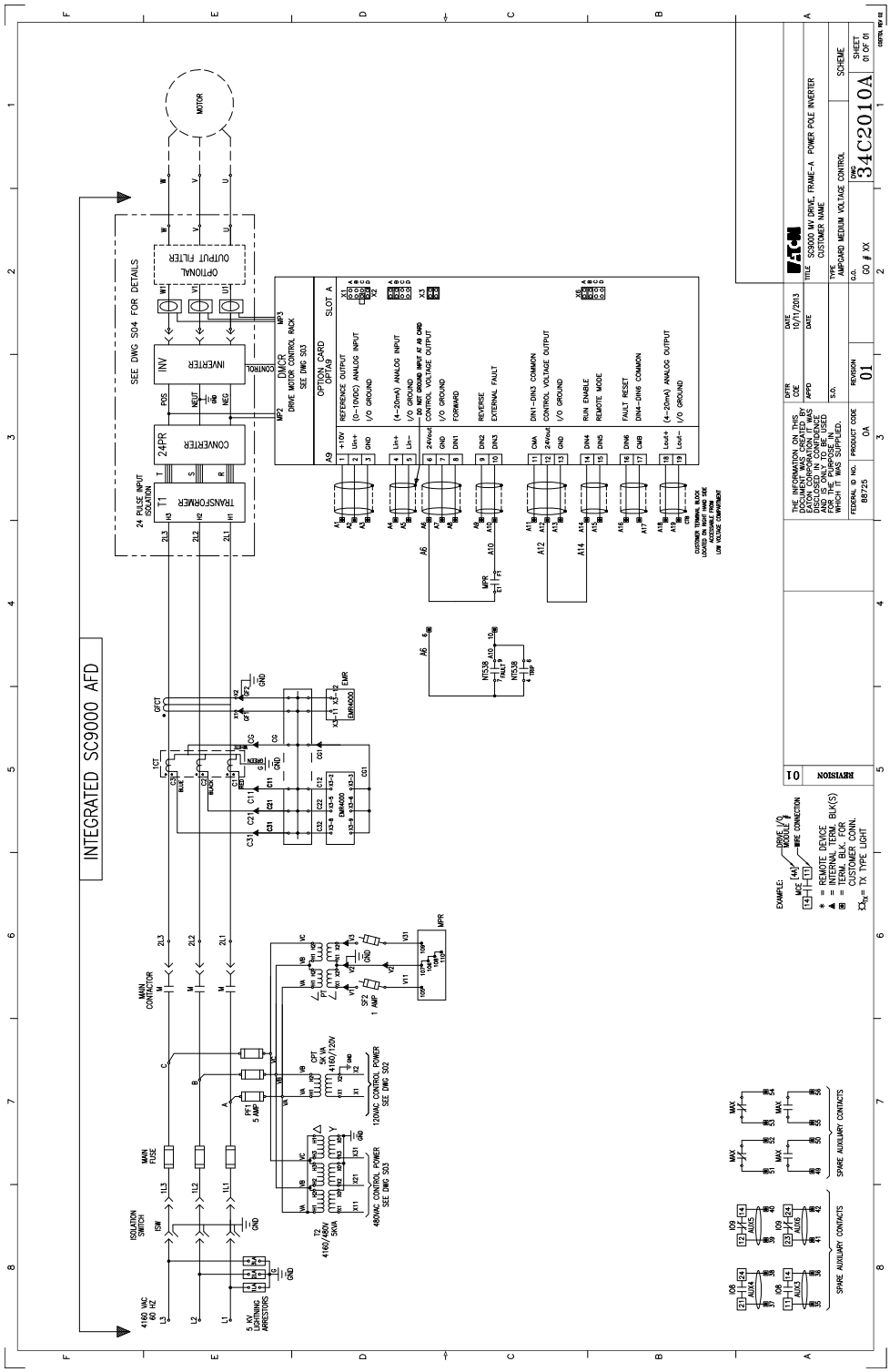


Figure 57. Typical Schematic for SC9000 EP AFD—Sheet 2

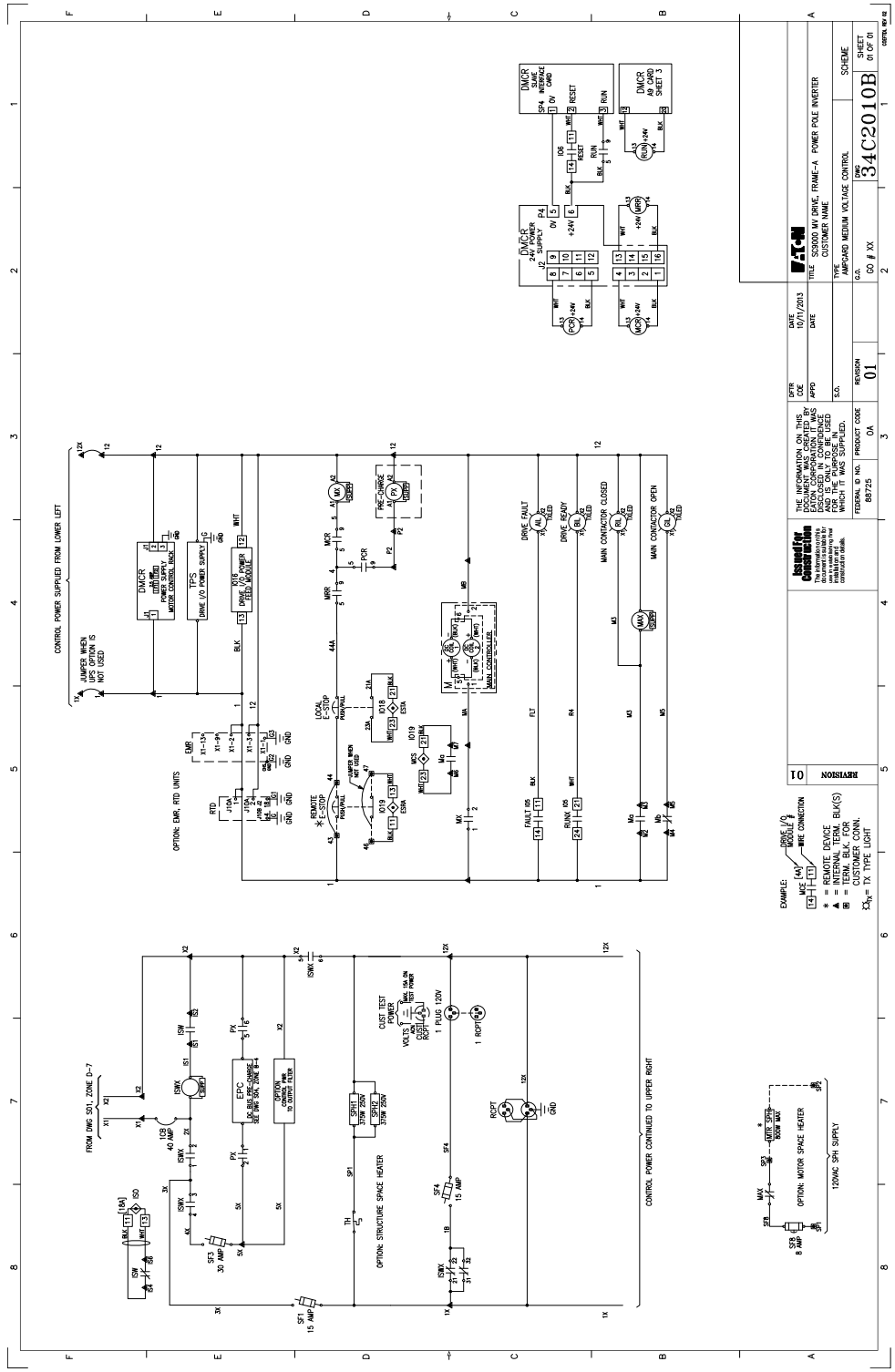


Figure 58. Typical Schematic for SC9000 EP AFD—Sheet 3

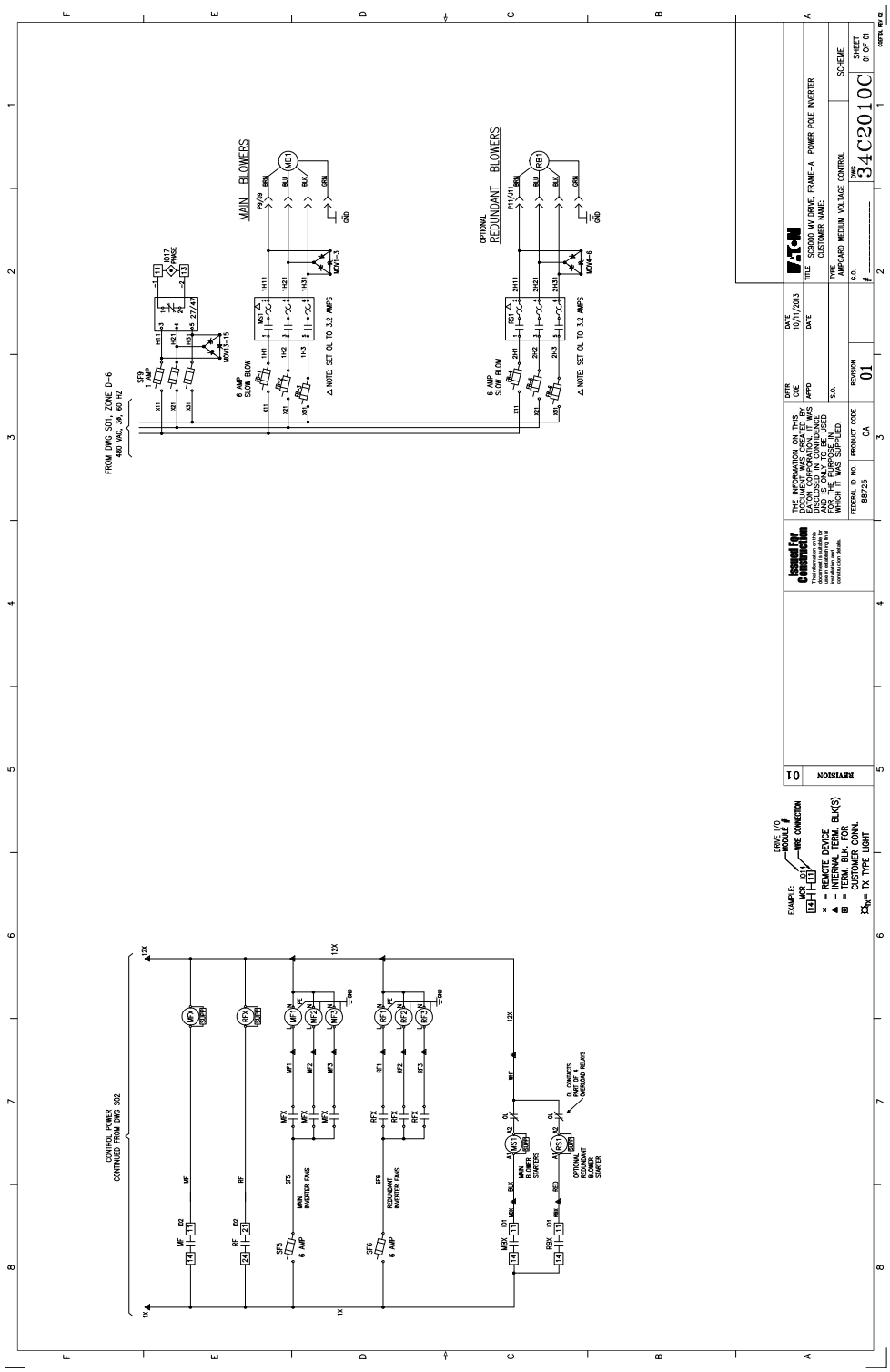


Figure 59. Typical Schematic for SC9000 EP AFD—Sheet 4

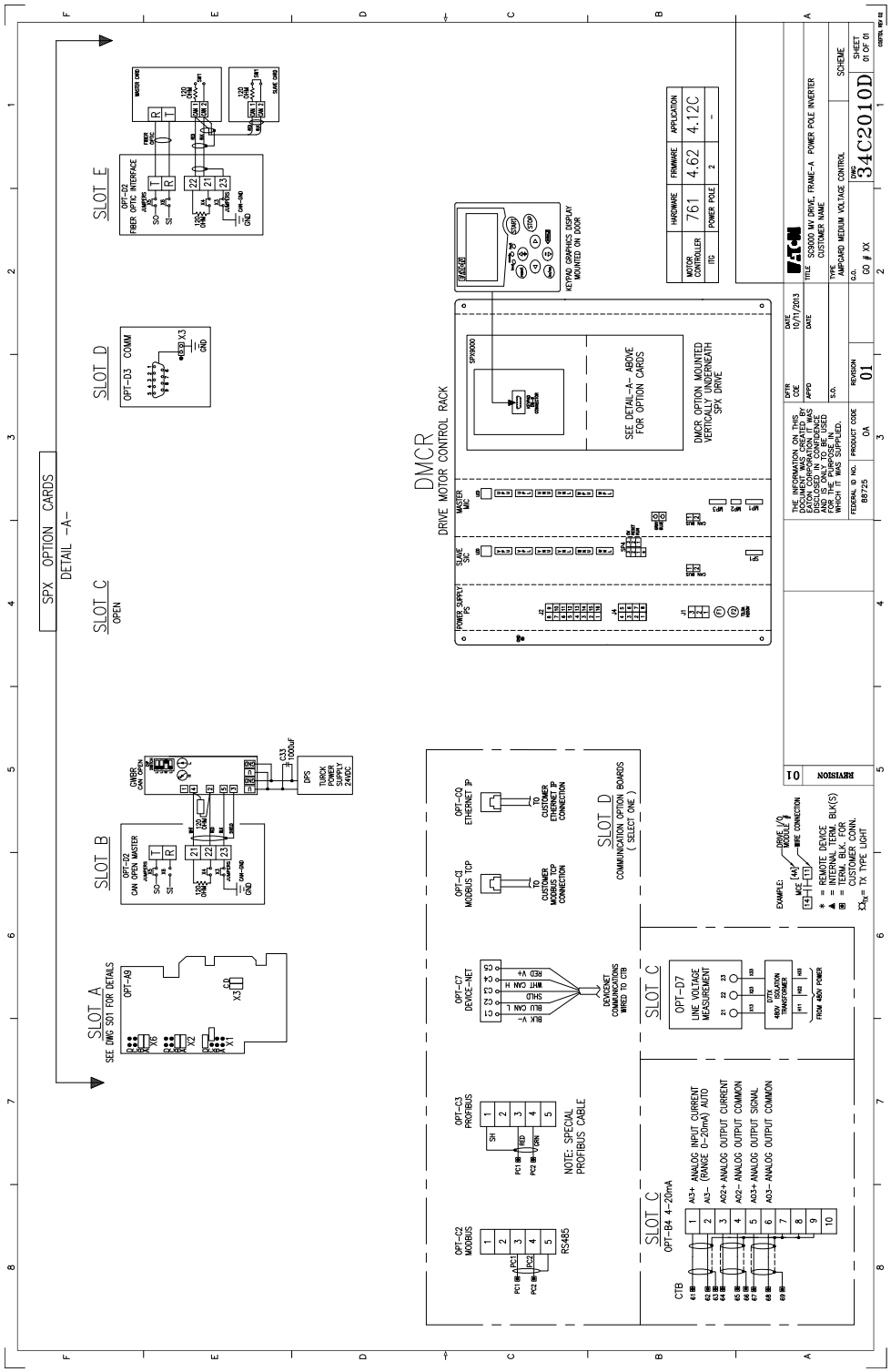


Figure 60. Typical Schematic for SC9000 EP AFD—Sheet 5

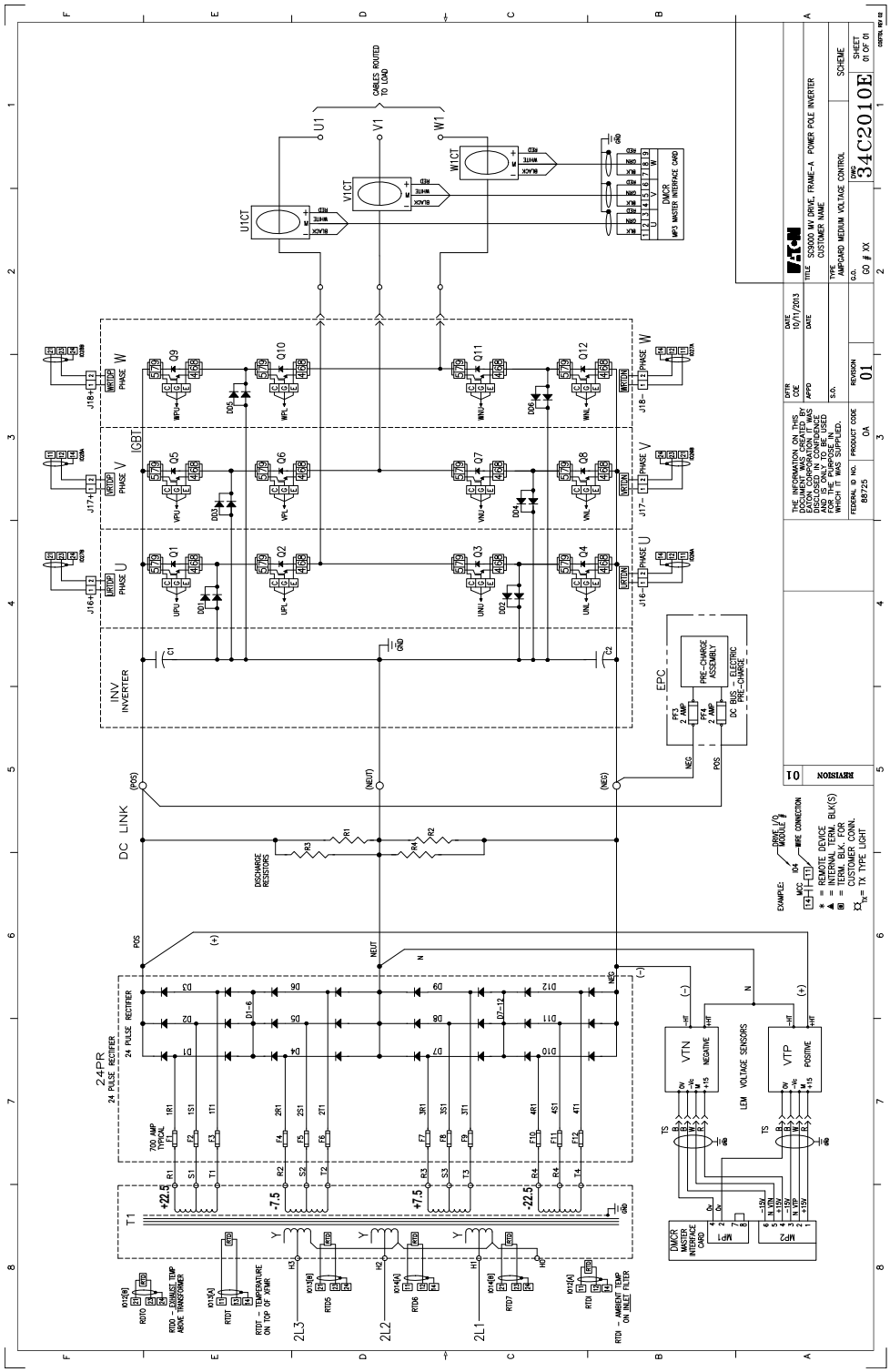


Figure 61. Typical Schematic for SC9000 EP AFD—Sheet 6

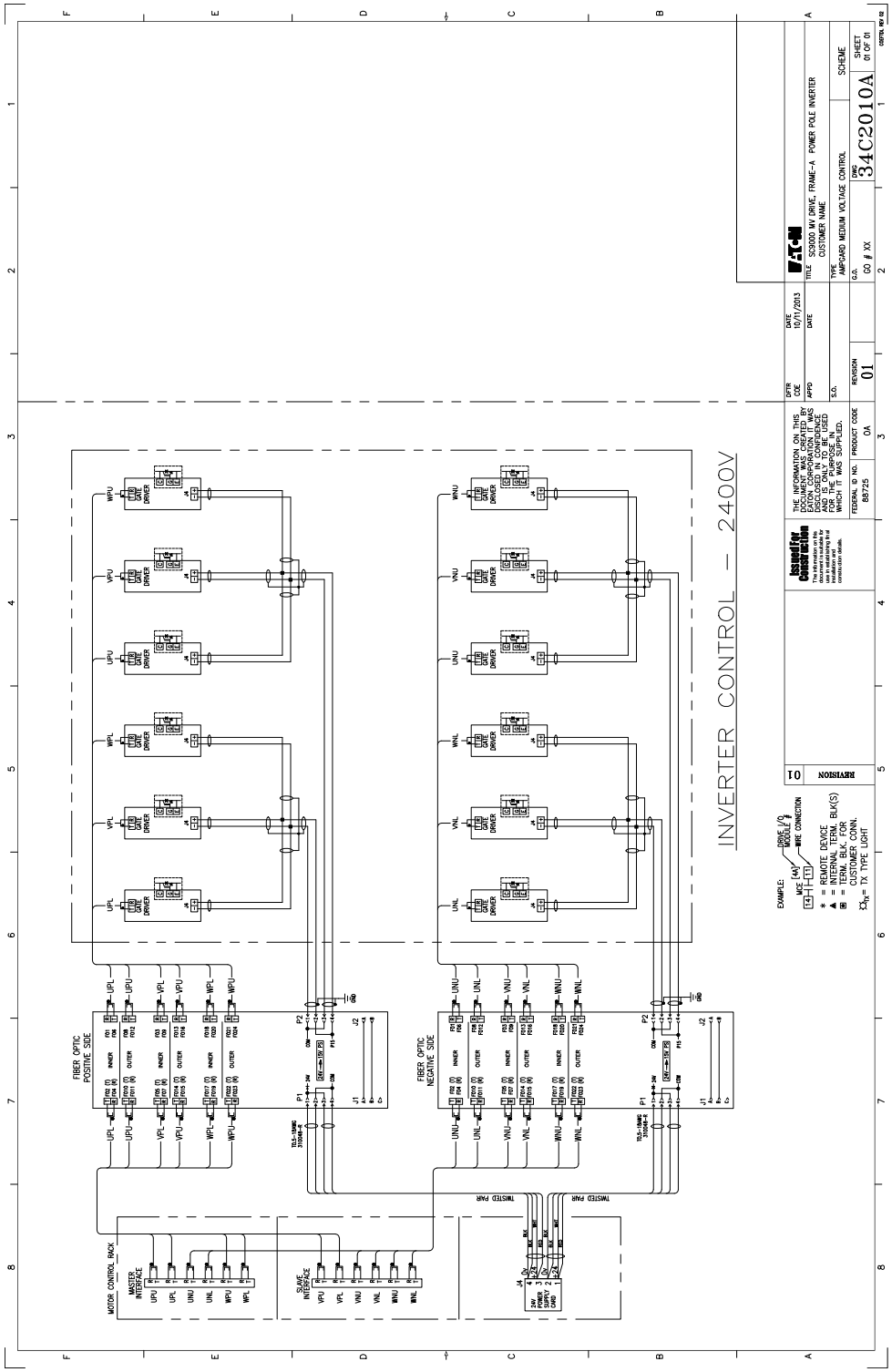

INVERTER CONTROL – 2400V
FIBER OPTIC POSITIVE SIDE
FIBER OPTIC NEGATIVE SIDE
MOTOR CONTROL RACK
MASTER INTERFACE
SLAVE INTERFACE
POWER SUPPLY CARD
TWISTED PAIR
TWISTED PAIR
REVISION
01
Issued for Construction
THE INFORMATION ON THIS DOCUMENT WAS CREATED BY EATON CORPORATION AND WAS DISCLOSED IN CONFIDENCE AND IS NOT TO BE USED FOR THE PURPOSE IN WHICH IT WAS SUPPLIED.
FEDERAL ID NO. 88725
PRODUCT CODE 0A
DRAWN DZE 10/11/2013
APPD DATE
S.O.
REVISION 01
TITLE SC9000 MV DRIVE, FRAME-A POWER POLE INVERTER CUSTOMER NAME
TYPE AMP/AIRD MEDIUM VOLTAGE CONTROL
G.O. GO # XX
DWG 34C2010A
SCHEME
SHEET 01 OF 01
EXAMPLE:
DRIVE I/O MODULE #3
WIRE CONNECTION
* = REMOTE DEVICE
▲ = INTERNAL TERM. BLK(S)
■ = TERM. BLK. FOR CUSTOMER CONN.
= TX TYPE LIGHT

Figure 62. Typical Schematic for SC9000 EP AFD—Sheet 7

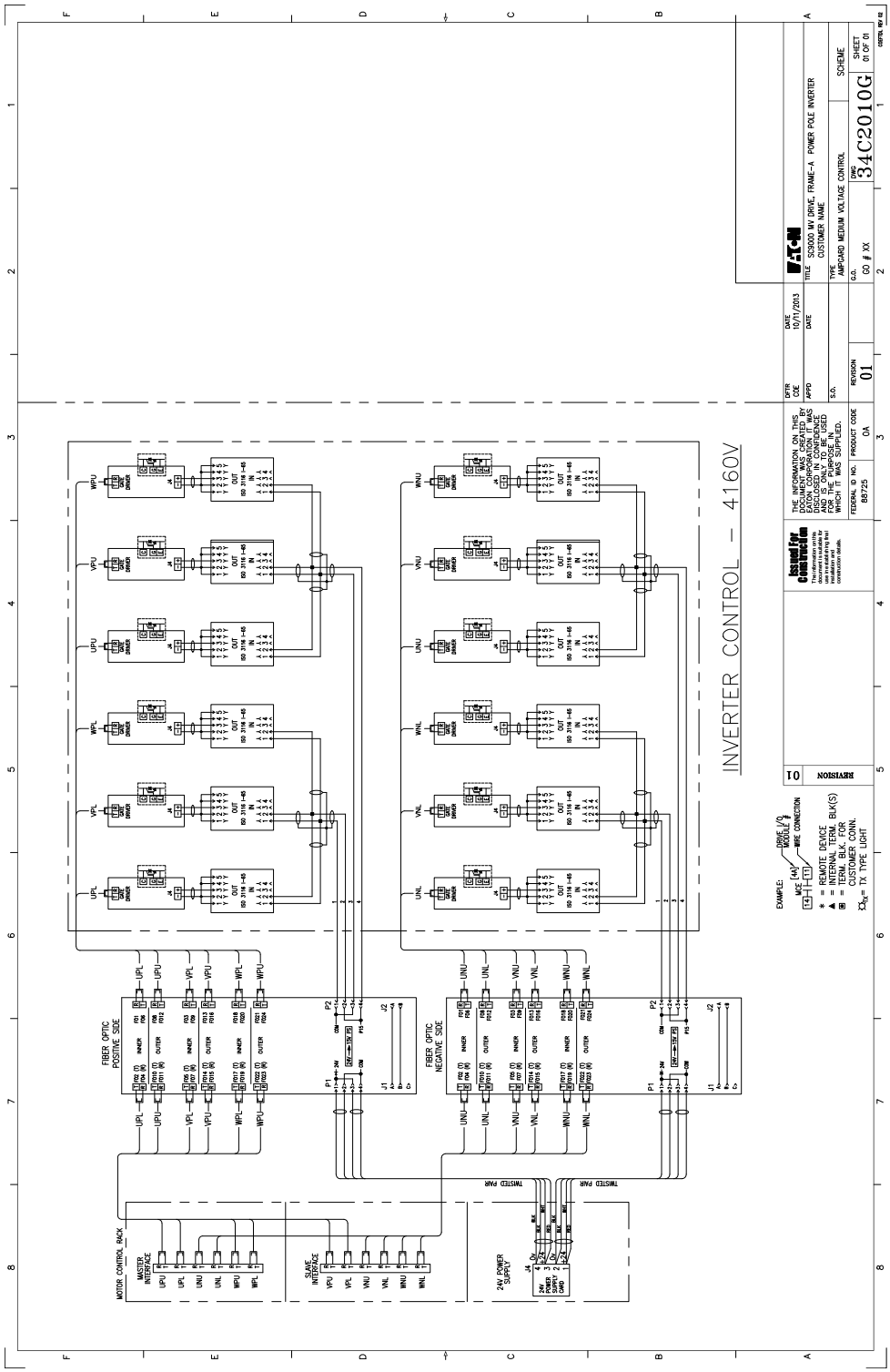


Figure 63. SC9000 EP AFD Frame A Dimensions and Incoming Line Layouts

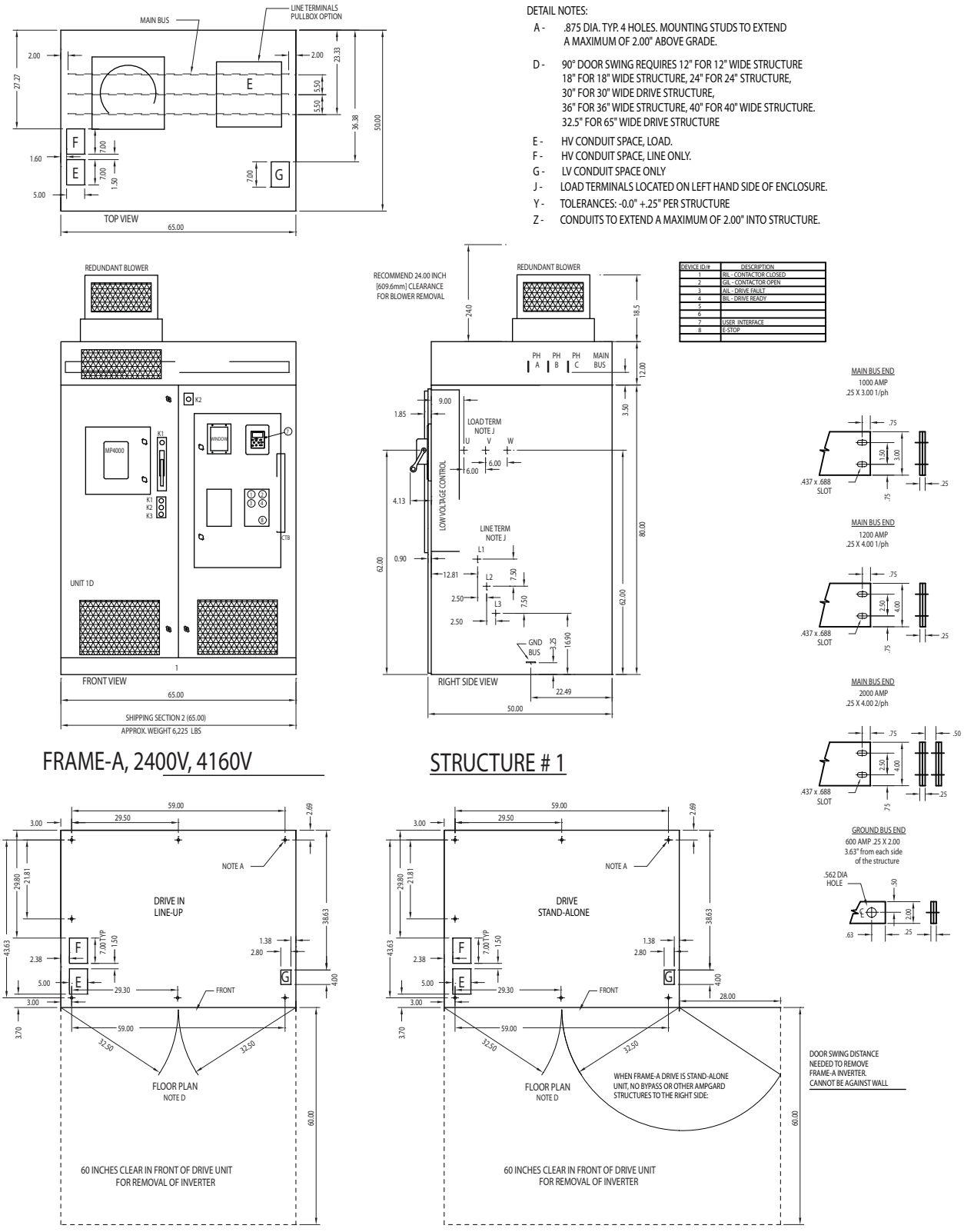

DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 30" FOR 30" WIDE DRIVE STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - LOAD TERMINALS LOCATED ON LEFT HAND SIDE OF ENCLOSURE.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
MAIN BUS
LINE TERMINALS PULLBOX OPTION
TOP VIEW
REDUNDANT BLOWER
RECOMMEND 24.00 INCH [609.6mm] CLEARANCE FOR BLOWER REMOVAL
UNIT 1D
FRONT VIEW
SHIPPING SECTION 2 (65.00)
APPROX. WEIGHT 6,225 LBS
LOAD TERM NOTE J
LINE TERM NOTE J
LOW VOLTAGE CONTROL
GND BUS
RIGHT SIDE VIEW
DEVICE ID/#
DESCRIPTION
1 RIL - CONTACTOR CLOSED
2 GIL - CONTACTOR OPEN
3 AIL - DRIVE FAULT
4 BIL - DRIVE READY
7 USER INTERFACE
8 E-STOP
MAIN BUS END
1000 AMP .25 X 3.00 1/ph
1200 AMP .25 X 4.00 1/ph
2000 AMP .25 X 4.00 2/ph
.437 x .688 SLOT
GROUND BUS END
600 AMP .25 X 2.00 3.63" from each side of the structure
.562 DIA HOLE
FRAME-A, 2400V, 4160V
STRUCTURE # 1
DRIVE IN LINE-UP
DRIVE STAND-ALONE
NOTE A
FRONT
FLOOR PLAN
NOTE D
60 INCHES CLEAR IN FRONT OF DRIVE UNIT FOR REMOVAL OF INVERTER
WHEN FRAME-A DRIVE IS STAND-ALONE UNIT, NO BYPASS OR OTHER AMPGARD STRUCTURES TO THE RIGHT SIDE:
DOOR SWING DISTANCE NEEDED TO REMOVE FRAME-A INVERTER. CANNOT BE AGAINST WALL

Figure 64. SC9000 EP AFD Frame B Dimensions and Incoming Line Layouts

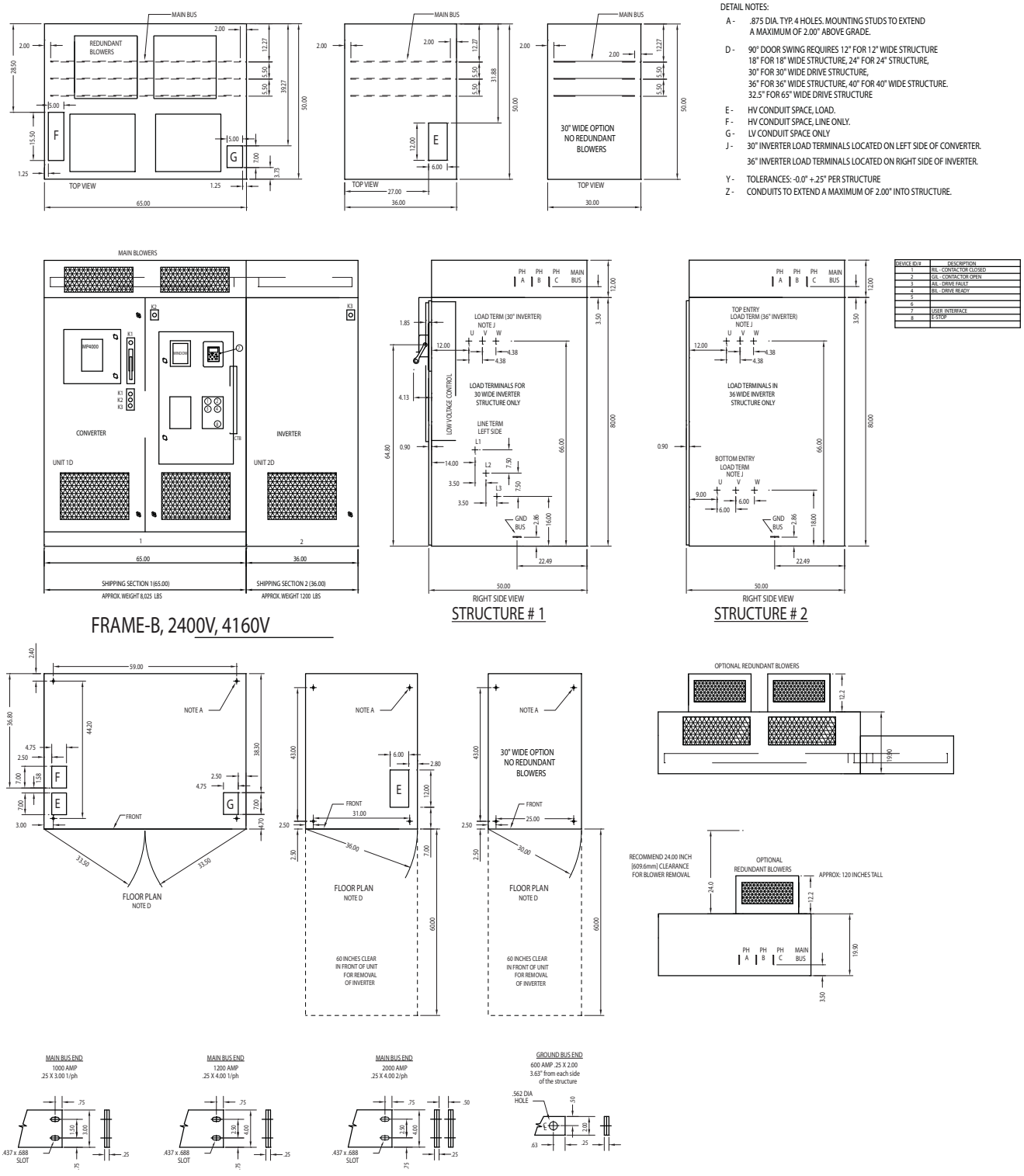

DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 30" FOR 30" WIDE DRIVE STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - 30" INVERTER LOAD TERMINALS LOCATED ON LEFT SIDE OF CONVERTER.
36" INVERTER LOAD TERMINALS LOCATED ON RIGHT SIDE OF INVERTER.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
MAIN BUS
REDUNDANT BLOWERS
TOP VIEW
30" WIDE OPTION NO REDUNDANT BLOWERS
MAIN BLOWERS
CONVERTER
INVERTER
UNIT 1D
UNIT 2D
SHIPPING SECTION 1(65.00)
APPROX. WEIGHT 8,025 LBS
SHIPPING SECTION 2 (36.00)
APPROX. WEIGHT 1200 LBS
LOAD TERM (30" INVERTER) NOTE J
LOAD TERMINALS FOR 30 WIDE INVERTER STRUCTURE ONLY
LOW VOLTAGE CONTROL
LINE TERM LEFT SIDE
RIGHT SIDE VIEW
STRUCTURE # 1
TOP ENTRY LOAD TERM (36" INVERTER) NOTE J
LOAD TERMINALS IN 36 WIDE INVERTER STRUCTURE ONLY
BOTTOM ENTRY LOAD TERM
STRUCTURE # 2
DEVICE ID/#
1 RIL - CONTACTOR CLOSED
2 GIL - CONTACTOR OPEN
3 AIL - DRIVE FAULT
4 BIL - DRIVE READY
7 USER INTERFACE
8 E-STOP
FRAME-B, 2400V, 4160V
NOTE A
FRONT
FLOOR PLAN
NOTE D
60 INCHES CLEAR IN FRONT OF UNIT FOR REMOVAL OF INVERTER
30" WIDE OPTION NO REDUNDANT BLOWERS
OPTIONAL REDUNDANT BLOWERS
RECOMMEND 24.00 INCH [609.6mm] CLEARANCE FOR BLOWER REMOVAL
APPROX: 120 INCHES TALL
MAIN BUS END
1000 AMP .25 X 3.00 1/ph
1200 AMP .25 X 4.00 1/ph
2000 AMP .25 X 4.00 2/ph
.437 x .688 SLOT
GROUND BUS END
600 AMP .25 X 2.00 3.63" from each side of the structure
.562 DIA HOLE

Figure 65. SC9000 EP AFD Frame C Dimensions and Incoming Line Layouts

0

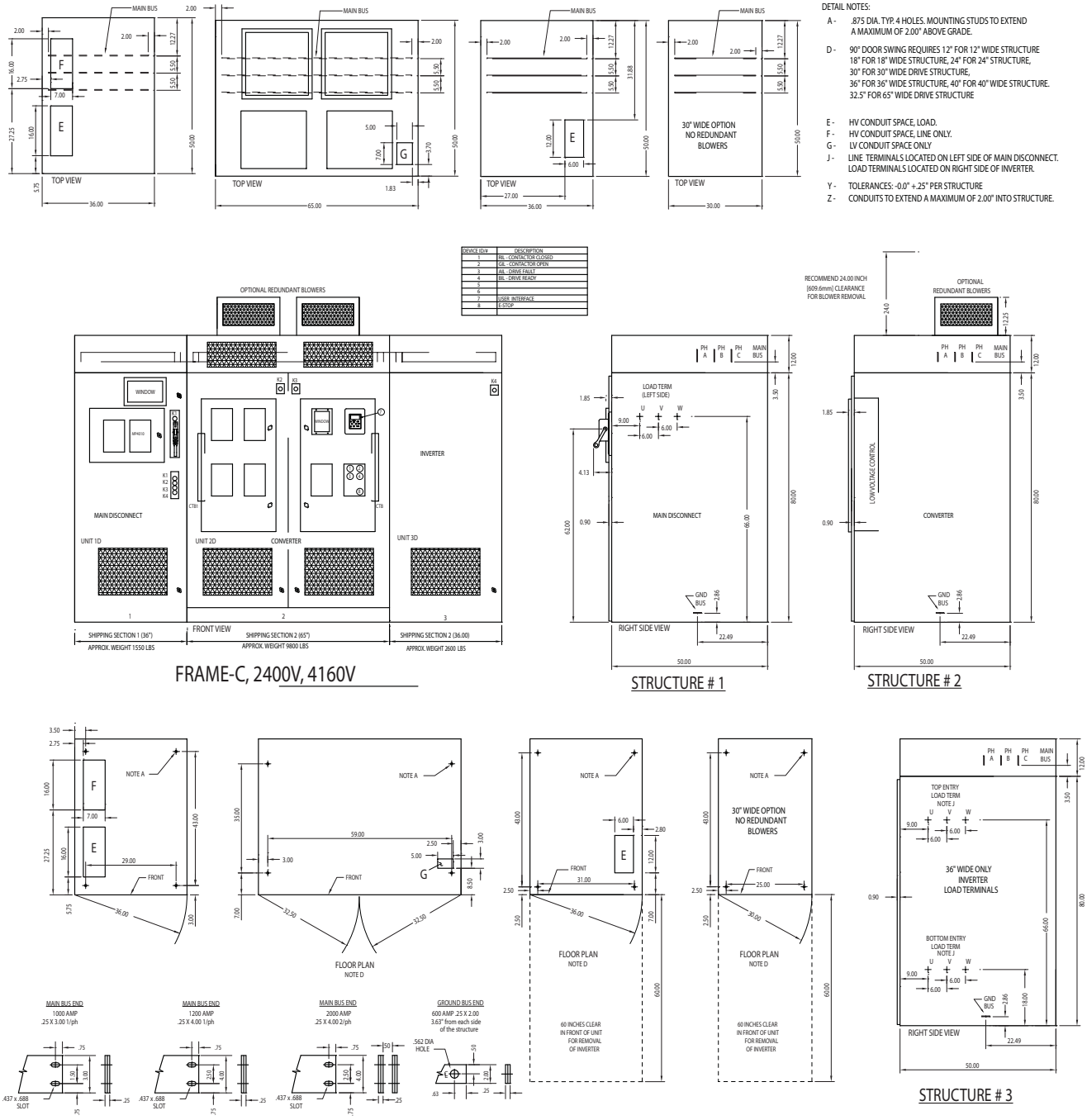

DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 30" FOR 30" WIDE DRIVE STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - LINE TERMINALS LOCATED ON LEFT SIDE OF MAIN DISCONNECT. LOAD TERMINALS LOCATED ON RIGHT SIDE OF INVERTER.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
MAIN BUS
TOP VIEW
30" WIDE OPTION NO REDUNDANT BLOWERS
OPTIONAL REDUNDANT BLOWERS
RECOMMEND 24.00 INCH [609.6mm] CLEARANCE FOR BLOWER REMOVAL
OPTIONAL REDUNDANT BLOWERS
DEVICE ID/#
DESCRIPTION
1 BIL - CONTACTOR CLOSED
2 GIL - CONTACTOR OPEN
3 AIL - DRIVE FAULT
4 BIL - DRIVE READY
5
6
7 USER INTERFACE
8 E-STOP
WINDOW
MAIN DISCONNECT
INVERTER
CONVERTER
UNIT 1D
UNIT 2D
UNIT 3D
FRONT VIEW
SHIPPING SECTION 1 (36")
APPROX. WEIGHT 1550 LBS
SHIPPING SECTION 2 (65")
APPROX. WEIGHT 9800 LBS
SHIPPING SECTION 2 (36.00)
APPROX. WEIGHT 2600 LBS
FRAME-C, 2400V, 4160V
LOAD TERM (LEFT SIDE)
RIGHT SIDE VIEW
STRUCTURE # 1
LOW VOLTAGE CONTROL
STRUCTURE # 2
NOTE A
FLOOR PLAN
NOTE D
60 INCHES CLEAR IN FRONT OF UNIT FOR REMOVAL OF INVERTER
MAIN BUS END
1000 AMP .25 X 3.00 1/ph
1200 AMP .25 X 4.00 1/ph
2000 AMP .25 X 4.00 2/ph
GROUND BUS END
600 AMP .25 X 2.00 3.63" from each side of the structure
.562 DIA HOLE
.437 x .688 SLOT
TOP ENTRY LOAD TERM NOTE J
36" WIDE ONLY INVERTER LOAD TERMINALS
BOTTOM ENTRY LOAD TERM NOTE J
STRUCTURE # 3

Figure 66. SC9000 EP AFD Frame D Dimensions and Incoming Line Layouts

S

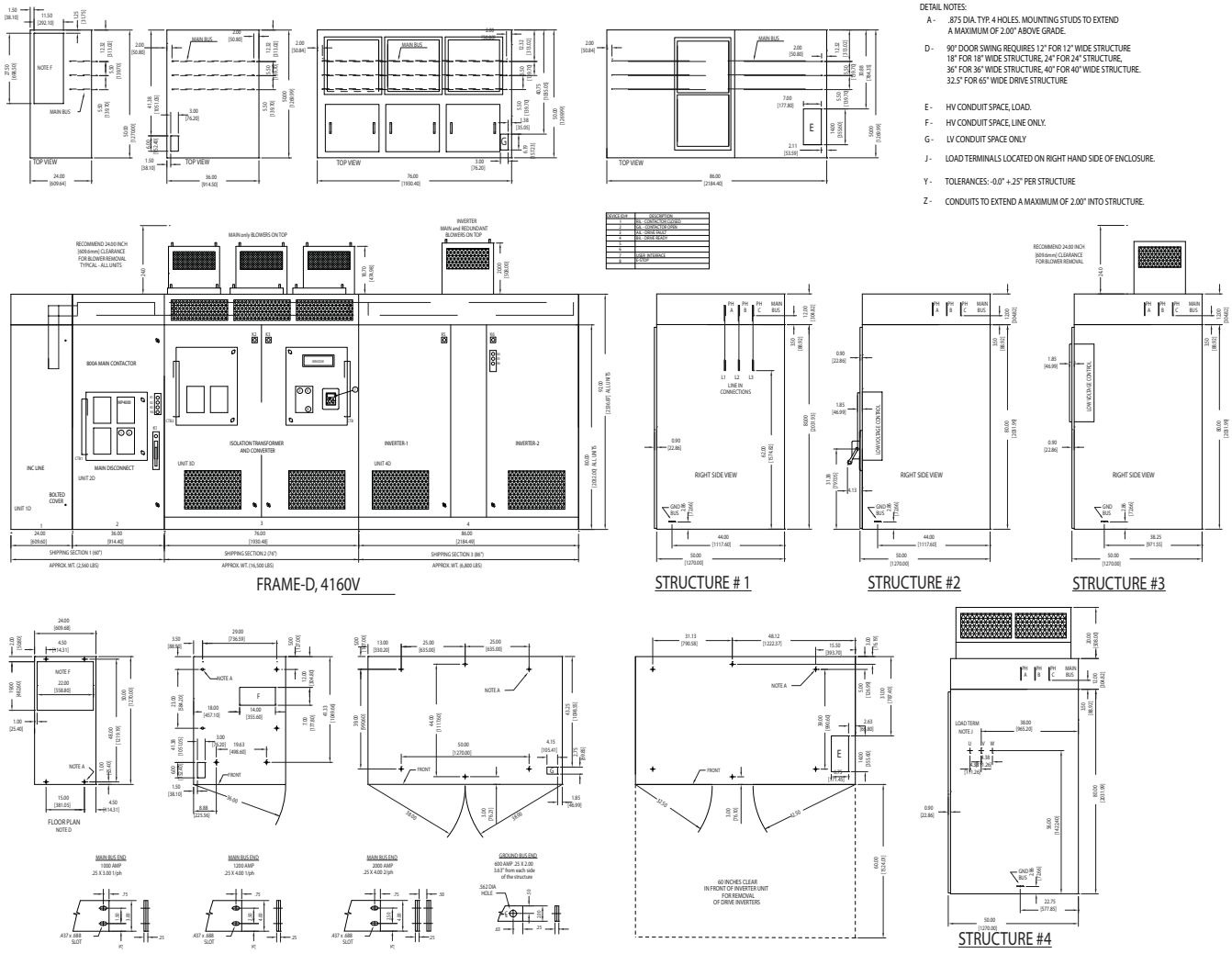

DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - LOAD TERMINALS LOCATED ON RIGHT HAND SIDE OF ENCLOSURE.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
TOP VIEW
MAIN BUS
NOTE F
RECOMMEND 24.00 INCH [609.6mm] CLEARANCE FOR BLOWER REMOVAL TYPICAL - ALL UNITS
MAIN only BLOWERS ON TOP
INVERTER MAIN and REDUNDANT BLOWERS ON TOP
800A MAIN CONTACTOR
ISOLATION TRANSFORMER AND CONVERTER
INVERTER-1
INVERTER-2
INC LINE
MAIN DISCONNECT
BOLTED COVER
UNIT 1D
UNIT 2D
UNIT 3D
UNIT 4D
SHIPPING SECTION 1 (60")
SHIPPING SECTION 2 (74")
SHIPPING SECTION 3 (86")
APPROX. WT. (2,560 LBS)
APPROX. WT. (16,500 LBS)
APPROX. WT. (6,800 LBS)
FRAME-D, 4160V
LINE IN CONNECTIONS
RIGHT SIDE VIEW
LOW VOLTAGE CONTROL
STRUCTURE # 1
STRUCTURE #2
STRUCTURE #3
FLOOR PLAN
NOTE D
NOTE A
FRONT
MAIN BUS END
1000 AMP .25 X 3.00 1/ph
1200 AMP .25 X 4.00 1/ph
2000 AMP .25 X 4.00 2/ph
GROUND BUS END
600 AMP .25 X 2.00
3.63" from each side of the structure
.56 DIA HOLE
60 INCHES CLEAR IN FRONT OF INVERTER UNIT FOR REMOVAL OF DRIVE INVERTERS
LOAD TERM NOTE J
STRUCTURE #4

Figure 67. SC9000 EP AFD Frame D Dimensions and Incoming Line Layouts

s

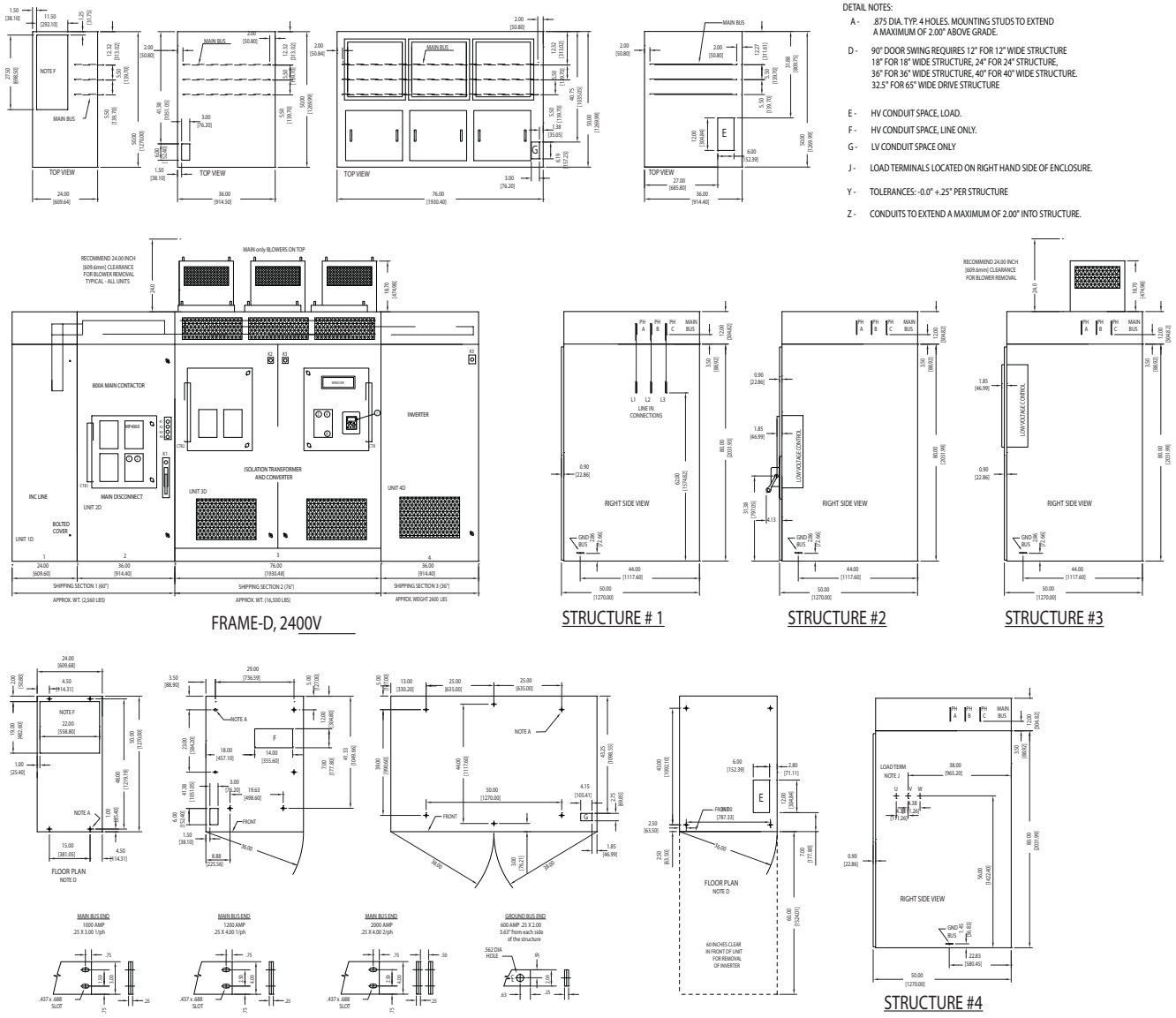
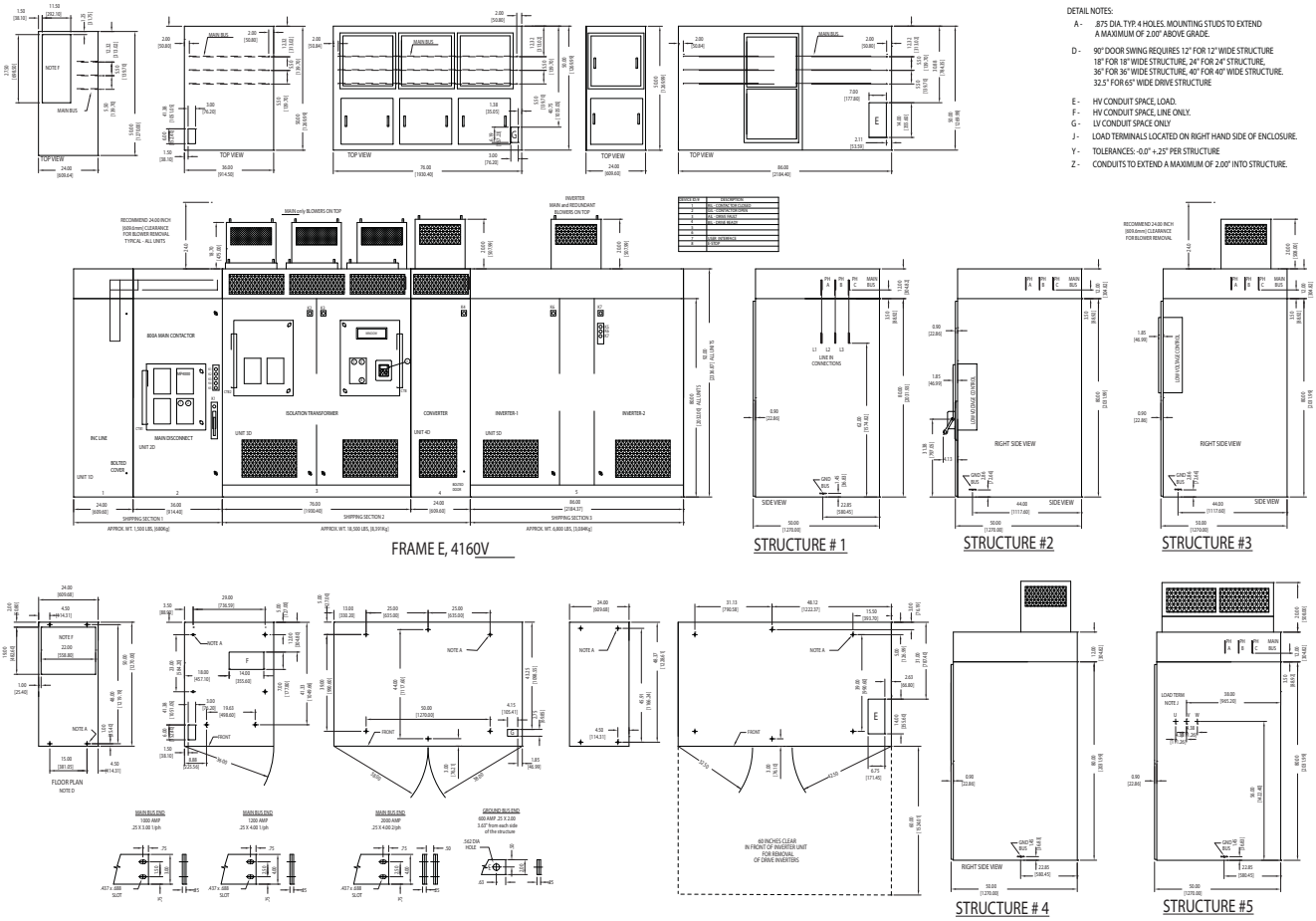

DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - LOAD TERMINALS LOCATED ON RIGHT HAND SIDE OF ENCLOSURE.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
TOP VIEW
MAIN BUS
NOTE F
RECOMMEND 24.00 INCH (609.6mm) CLEARANCE FOR BLOWER REMOVAL TYPICAL - ALL UNITS
MAIN only BLOWERS ON TOP
800A MAIN CONTACTOR
INVERTER
ISOLATION TRANSFORMER AND CONVERTER
MAIN DISCONNECT
INC LINE
BOLTED COVER
UNIT 1D
UNIT 2D
UNIT 3D
UNIT 4D
SHIPPING SECTION 1 (60")
SHIPPING SECTION 2 (76")
SHIPPING SECTION 3 (36")
APPROX. WT. (2,560 LBS)
APPROX. WT. (16,500 LBS)
APPROX. WEIGHT 2600 LBS
FRAME-D, 2400V
PH A
PH B
PH C
MAIN BUS
LINE IN CONNECTIONS
RIGHT SIDE VIEW
LOW VOLTAGE CONTROL
STRUCTURE # 1
STRUCTURE #2
STRUCTURE #3
FLOOR PLAN
NOTE D
NOTE A
NOTE F
FRONT
60 INCHES CLEAR IN FRONT OF UNIT FOR REMOVAL OF INVERTER
LOAD TERM
NOTE J
MAIN BUS END
1000 AMP .25 X 3.00 1/ph
1200 AMP .25 X 4.00 1/ph
2000 AMP .25 X 4.00 2/ph
GROUND BUS END
600 AMP .25 X 2.00
3.63" from each side of the structure
.562 DIA HOLE
STRUCTURE #4

Figure 68. SC9000 EP AFD Frame E Dimensions and Incoming Line Layouts

S


DETAIL NOTES:
A - .875 DIA. TYP. 4 HOLES. MOUNTING STUDS TO EXTEND A MAXIMUM OF 2.00" ABOVE GRADE.
D - 90° DOOR SWING REQUIRES 12" FOR 12" WIDE STRUCTURE 18" FOR 18" WIDE STRUCTURE, 24" FOR 24" STRUCTURE, 36" FOR 36" WIDE STRUCTURE, 40" FOR 40" WIDE STRUCTURE. 32.5" FOR 65" WIDE DRIVE STRUCTURE
E - HV CONDUIT SPACE, LOAD.
F - HV CONDUIT SPACE, LINE ONLY.
G - LV CONDUIT SPACE ONLY
J - LOAD TERMINALS LOCATED ON RIGHT HAND SIDE OF ENCLOSURE.
Y - TOLERANCES: -0.0" +.25" PER STRUCTURE
Z - CONDUITS TO EXTEND A MAXIMUM OF 2.00" INTO STRUCTURE.
TOP VIEW
MAIN BUS
NOTE F
RECOMMEND 24.00 INCH (609.6mm) CLEARANCE FOR BLOWER REMOVAL TYPICAL - ALL UNITS
MAIN poly BLOWERS ON TOP
INVERTER MAIN and REDUNDANT BLOWERS ON TOP
800A MAIN CONTACTOR
ISOLATION TRANSFORMER
CONVERTER
INVERTER-1
INVERTER-2
INC LINE
MAIN DISCONNECT
BOLTED COVER
UNIT 1D
UNIT 2D
UNIT 3D
UNIT 4D
UNIT 5D
SHIPPING SECTION 1
SHIPPING SECTION 2
SHIPPING SECTION 3
APPROX. WT. 1,500 LBS. (680Kg)
APPROX. WT. 18,500 LBS. (8,391Kg)
APPROX. WT. 6,800 LBS. (3,084Kg)
FRAME E, 4160V
LINE IN CONNECTIONS
SIDE VIEW
STRUCTURE # 1
RIGHT SIDE VIEW
STRUCTURE #2
STRUCTURE #3
FLOOR PLAN
NOTE D
NOTE A
NOTE F
FRONT
MAIN BUS END
1600 AMP .25 X 3.00 1 ph
MAIN BUS END
1200 AMP .25 X 4.00 1 ph
MAIN BUS END
2000 AMP .25 X 4.00 2 ph
GROUND BUS END
600 AMP .25 X 2.00
3.65" from each side of the structure
.562 DIA HOLE
.437 x .688 SLOT
60 INCHES CLEAR IN FRONT OF INVERTER UNIT FOR REMOVAL OF DRIVE INVERTERS
STRUCTURE # 4
STRUCTURE #5

Appendix B: Optional Equipment

Chapter 1: Introduction

Purpose

This user manual addendum covers the installation, operation, and maintenance of selected SC9000 EP Medium Voltage Adjustable Frequency Drive optional equipment. It does not cover all possible contingencies, variations, and details that may arise during installation, operation, and maintenance of this equipment.

The SC9000 EP can be equipped with several optional features. This addendum addresses these features:

- dV/dt Filter
- Sine Filter
- Synchronous Transfer
- Synchronous Motor Control
- High Voltage Input
- Bypass Control

Optional Features Summary

dV/dt Filter

Standard induction motors driven by Adjustable Frequency Drives can experience excessive induced voltages at the motor under certain cable length conditions. An SC9000 EP dV/dt filter, selected for the motor's ratings and cable length, reduces these voltages, and makes longer cable runs possible with satisfactory operation.

Inverter-duty motors driven by Adjustable Frequency Drives also can experience excessive induced voltages at the motor if cable length is excessive. For inverter-duty motors, the circumstances when these voltages occur are different, but an SC9000 EP dV/dt filter also addresses these conditions.

Sine Filter

Total Harmonic Distortion, or THD, is a measurement of the amount the addition of other frequency waves corrupts a wave shape.

The SC9000 EP Sine Filter design reduces the drive output THD to less than 5% on both output voltage and current. Although its purpose is harmonic distortion reduction, the sine filter will also reduce the drive output dV/dt to less than 10 volts per microsecond.

Eaton Contact Information

For the location of your nearest Eaton sales office or distributor, call toll-free 1-800-525-2000 or log on to www.eaton.com. Eaton's Engineering Services & Systems (EESS) can be reached at 1-800-498-2678.

Synchronous Transfer System

With additional equipment, the SC9000 EP can provide synchronous transfer control to a multiple-motor system. For any number of motors, this system individually starts and accelerates each motor, matches its voltage, frequency and phase angle to a utility power bus, and transfers the motor from the SC9000 EP to the utility bus. In addition, the synchronous transfer system can transfer any connected motor's power source from the utility bus back to the SC9000 EP and run or stop it.

Synchronous Motor Control

The SC9000 EP Adjustable Frequency Drive can power synchronous motors. Additional power and control components power the motor's rotor field.

While the Ampgard Motor Control product line offers four different versions of synchronous motor field excitation for motor starters, the SC9000 EP offers synchronous motor field control for brushless motors only.

High Voltage Input

The SC9000 EP can deliver 2400V, 3300V or 4160V output voltages, and can accommodate input voltages between 2.4 kV and 13.8 kV. When input voltages above 6.9 kV are required, the SC9000 EP is equipped with an additional 72-inch wide cabinet to incorporate a 95 kV BIL incoming line and a 15 kV input contactor.

Bypass System

The Ampgard system offers two systems for Bypass control: Full Voltage Bypass and **R**educed **V**oltage **S**olid **S**tate Bypass.

Full Voltage Bypass serves as a backup to the SC9000 EP AFD and can run a connected using a full voltage starter while the AFD is down.

RVSS Bypass starts the connected motor using a reduced-voltage solid-state starter technology while the AFD is down.

Refer to the specific order drawings supplied with your drive system for details on which devices are part of your equipment.

Documentation Reference

For further information on installation and application, refer to the applicable technical data, publications, and/or industry standards. Download Eaton electronic information from www.eaton.com.

Chapter 2: dV/dt Filter

The SC9000 EP dV/dt filter is a combination of reactors, capacitors and resistors that reduces the sharp change in voltages due to IGBT switching. Smoothing the voltage spikes reduces the high frequency ringing, lowers the voltage added to the drive output and reduces the effects on motor insulation and bearings when cable lengths are excessive.

The dV/dt filter reduces high frequency ringing on the SC9000 EP output. It does not reduce drive output Total Harmonic Distortion. The SC9000 EP Sine Filter serves that purpose.

When to Use a dV/dt Filter

For motors used with SC9000 EP drives, the decision to apply a dV/dt filter depends upon the motor used and the connecting cable lengths between the SC9000 EP and the motor.

Longer cable runs are possible with a dV/dt Filter present. Permissible lengths depend upon the type of motor used.

dV/dt Use on a Standard Motor

If a standard (non-inverter rated) motor is used,

- Apply a dV/dt filter to a 2400V motor whenever the connecting cable lengths are greater than 60 feet
- Apply a dV/dt filter to a 4160V motor whenever the connecting cable lengths are greater than 120 feet
- Apply **only** a Sine Filter (see Chapter 3) whenever the cable length is greater than 1250 feet

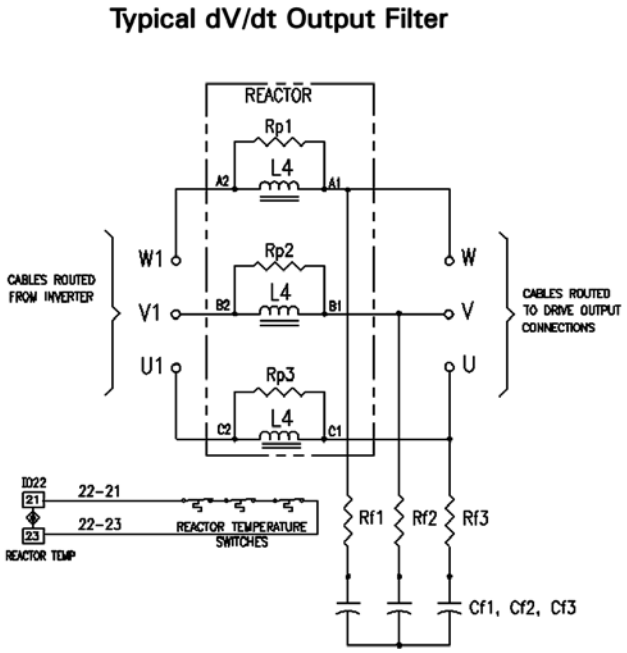
dV/dt Use on an Inverter Duty Motor

- Apply a dV/dt filter to a 2400V motor whenever the connecting cable lengths are greater than 150 feet
- Apply a dV/dt filter to a 4160V motor whenever the connecting cable lengths are greater than 300 feet.
- Apply **only** a Sine Filter (see Chapter 3) whenever the cable length is greater than 1250 feet

Contact Eaton if the motor cable length is greater than what is recommended above and the optional output filter has not been supplied.

Figure 69 shows a representative dV/dt elementary diagram.

Figure 69. Typical dV/dt Filter



Example Showing the Effects of a dV/dt Filter

Figure 70 shows a representative SC9000 EP voltage step output (in green) with a corresponding dV/dt filter voltage output (in purple). In this example, the rate of change of drive output voltage (dV/dt) has decreased by about 23 times.

Figure 70. dV/dt Filter Effect on Drive Output

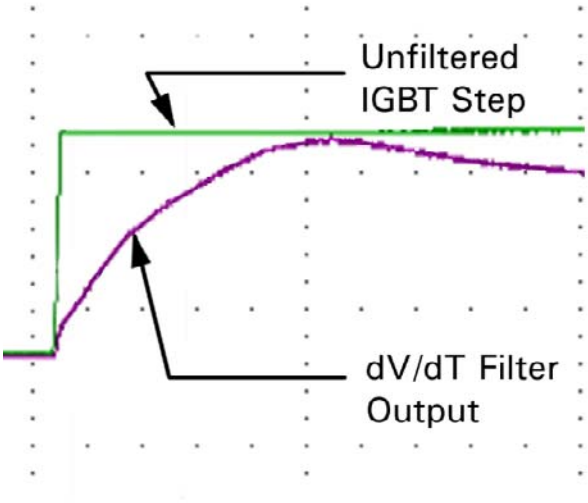


Figure 71 shows an example dV/dt filter in its cabinet.

Figure 71. dV/dt Filter in Cabinet

SC9000 EP dV/dt Filters and Ratings

SC9000 EP dV/dt Filter designs are based upon drive rated voltage and current. Eaton application engineers select a filter during the project design process. **Tables 24** and **25** show SC9000 EP dV/dt filter models.

Table 24. 2300V dV/dt Filters

Catalog Number 39C2078	Drive Power (HP)	Filter Rating (A)	Cabinet Size (H x W x D)	Watts Loss (W)
G43	300	71	92 x 24 x 50	1024
G44	400	93	92 x 24 x 50	1084
G45	500	116	92 x 24 x 50	1102
G46	600	136	92 x 36 x 50	1383
G48	800	180	92 x 36 x 50	1440
G410	1000	225	92 x 36 x 50	1514
G412	1250	279	92 x 36 x 50	1658
G415	1500	335	92 x 36 x 50	1802
G420	2000	446	92 x 36 x 50	2129
G425	2500	558	92 x 36 x 50	2226

Table 25. 4160V dV/dt Filters

Catalog Number 39C2028	Drive Power (HP)	Filter Rating (A)	Cabinet Size (H x W x D)	Watts Loss (W)
G43	300	44.7	92 x 24 x 50	1282
G44	400	57.0	92 x 24 x 50	1360
G45	500	65.1	92 x 24 x 50	1357
G46	600	81.5	92 x 36 x 50	1674
G48	800	101	92 x 36 x 50	2029
G410	1000	125	92 x 36 x 50	2011
G412	1250	159	92 x 36 x 50	2163
G415	1500	186	92 x 36 x 50	3348
G420	2000	248	92 x 36 x 50	3444
G425	2500	310	92 x 36 x 50	3592
G430	3000	373	92 x 40 x 50	4843
G435	3500	434	92 x 40 x 50	4632
G442	4250	527	92 x 40 x 50	6731
G450	5000	633	92 x 40 x 50	7892
G460	6000	760	92 x 40 x 50	8033

dV/dt Filter as Part of the SC9000 EP Lineup

During the project application and design process, the intended cable lengths and motor type selected will determine whether to apply a dV/dt filter. If your project needs a dV/dt filter, Eaton application engineers will select a filter for the intended drive, motor and installation.

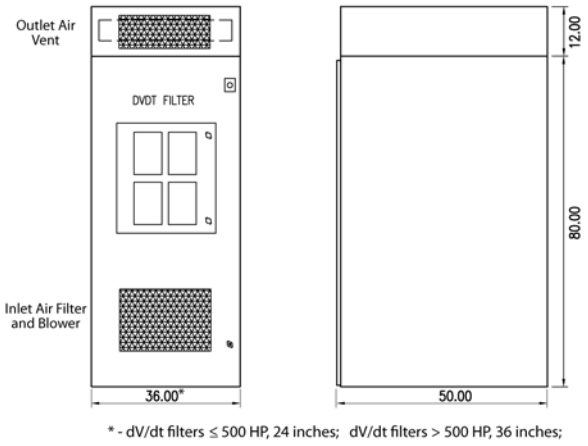
Physical Location in SC9000 EP Drive

The SC9000 EP dV/dt filter, when present, is typically located in the SC9000 EP panel lineup, adjacent to and downstream of the inverter cabinet. However, it can be located remotely depending on the application and installation constraints.

Filter Cabinet Outline

Figure 72 shows a typical cabinet outline for a dV/dt Filter.

Figure 72. dV/dt Representative Cabinet Outlines



Figures 73 and **74** show the dV/dt filter cabinet location and power flow position in the SC9000 EP.

Figure 73. dV/dt Filter Cabinet in SC9000 EP Lineup

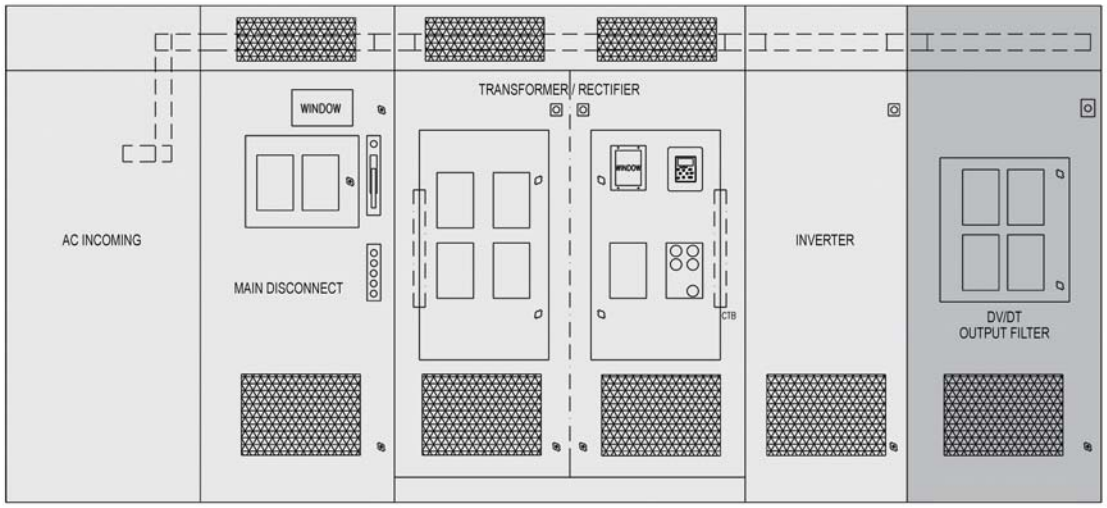
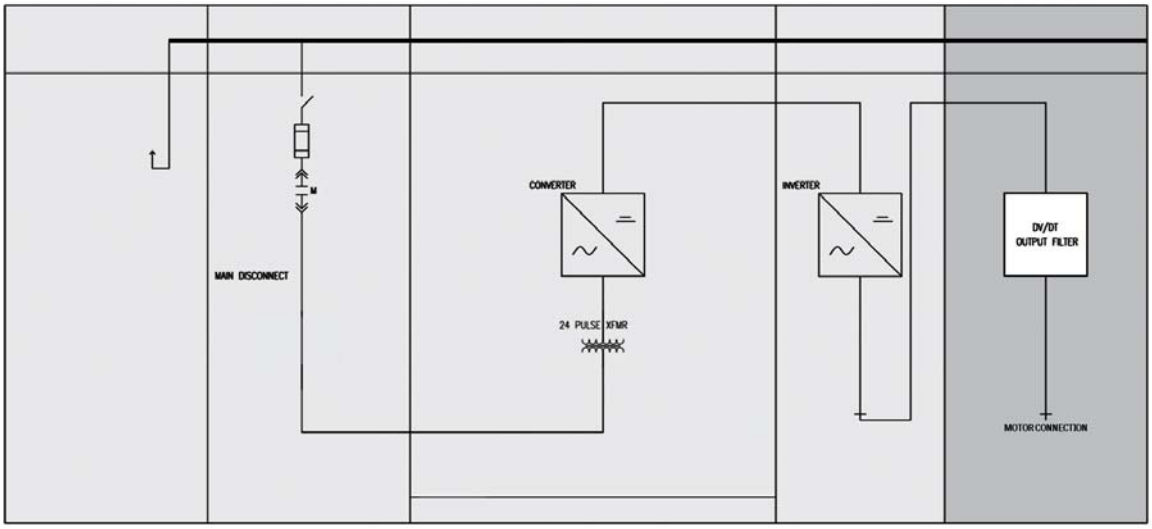


Figure 74. dV/dt Filter Power Flow



dV/dt Cooling Requirements

The installed filter's cabinet cooling system provides its required cooling. This system consists of an inlet air filter and outlet air fan, located in the cabinet door, and an air outlet vent on top of the control cabinet. The filter and fan require periodic maintenance for maximum efficiency.

Maintenance

Inspect the dV/dt filter cabinet cooling system periodically to assure maximum uptime and effectiveness. Inspect the cooling fan and inlet air filter at least once every three months. Clean the filters with an air jet and dust the fan to prevent dust buildup in the fan motor and bearings. Replace the fan every three to five years.

Troubleshooting

The dV/dt Filter includes reactor thermal switches. When a dV/dt Filter is included in the SC9000 EP, these sensors connect to the SC9000 EP I/O and the drive application is programmed to monitor them. Detection of a thermal switch opening causes a drive shutdown and a fault message to be displayed and recorded.

Replacement Parts

Table 26 shows replacement part numbers.

Table 26. Replacement Parts

Part Number	Description
W2E250-HJ32-0	Fan, WE250, 1P, 115V, 60HZ, 50C C
478C779H01	Intake Filter
Contact Eaton for Project-specific part	Reactor (Includes Thermal Switch and Thermal Sensor)

O&M Technical References

For additional information about the SC9000 EP, refer to this SC9000 EP User Manual, IB02004001E.

Chapter 3: Sine Filter

Sine Filter Definition

A Sine Filter is an SC9000 EP system element designed to reduce Total Harmonic Distortion of the output. Total Harmonic Distortion, or THD, is a measurement of the amount the addition of other frequency waves corrupts a wave shape. THD measures the power quality of electric power systems.

Unlike the dV/dt filter, which works to reduce high-frequency drive output components, the Sine Filter reduces specific lower-frequency harmonics to produce a more sinusoidal drive output voltage and current.

Reducing Total Harmonic Distortion of the voltage and current delivered to a motor can decrease heating and increase efficiency. Harmonics, if present, will increase the electrical losses, and increase motor heating.

Sine Filter Purpose

The SC9000 EP Sine Filter design reduces the drive output THD to less than 5% on both output voltage and current, for loads above 30% of rated. Although its purpose is harmonic distortion reduction, the sine filter will also reduce the drive output dV/dt.

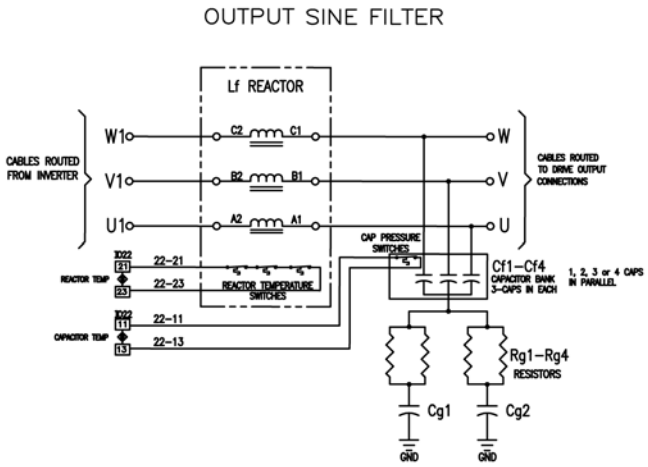
With the Sine Filter applied, the only limitation on connecting cable lengths is the voltage drop between the drive and the motor.

Sine Filter Design

The SC9000 EP Sine Filter is composed of inductors, capacitors and resistors. The inductors and capacitors assemblies include protective sensing devices.

Figure 75 shows a representative Sine Filter diagram.

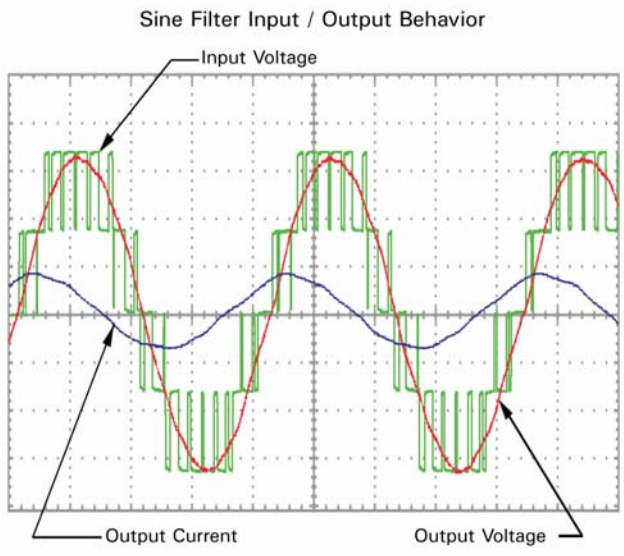
Figure 75. Typical Sine Filter Elementary Diagram



Representative Sine Filter Performance

Figure 76 shows an example of SC9000 EP output performance without and with the Sine Filter.

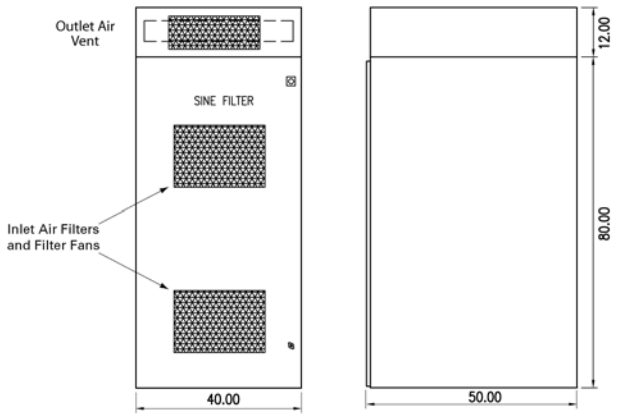
Figure 76. Example Before and After Sine Filter Output



Sine Filter Location in the SC9000 EP Drive

Sine filters mount in their own cabinets, and come with cabinet cooling fans and inlet air filters. Due to their weight, sine filter inductors mount in the cabinet bottom, with the resistors and capacitors on a shelf above them.

Figure 77. Sine Filter Panel Layout



Figures 78 and **79** show a typical SC9000 EP lineup with a Sine Filter included. The Sine Filter mounts adjacent to the inverter cabinet in an SC9000 EP lineup.

Figure 78. Sine Filter Added to SC9000 EP Lineup

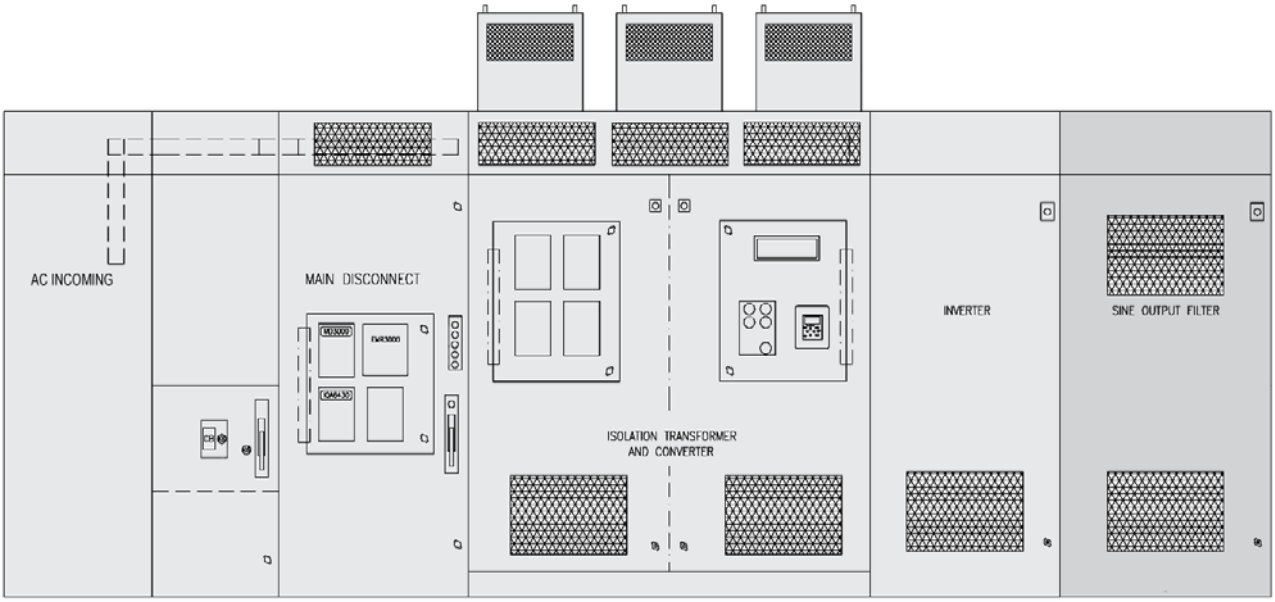
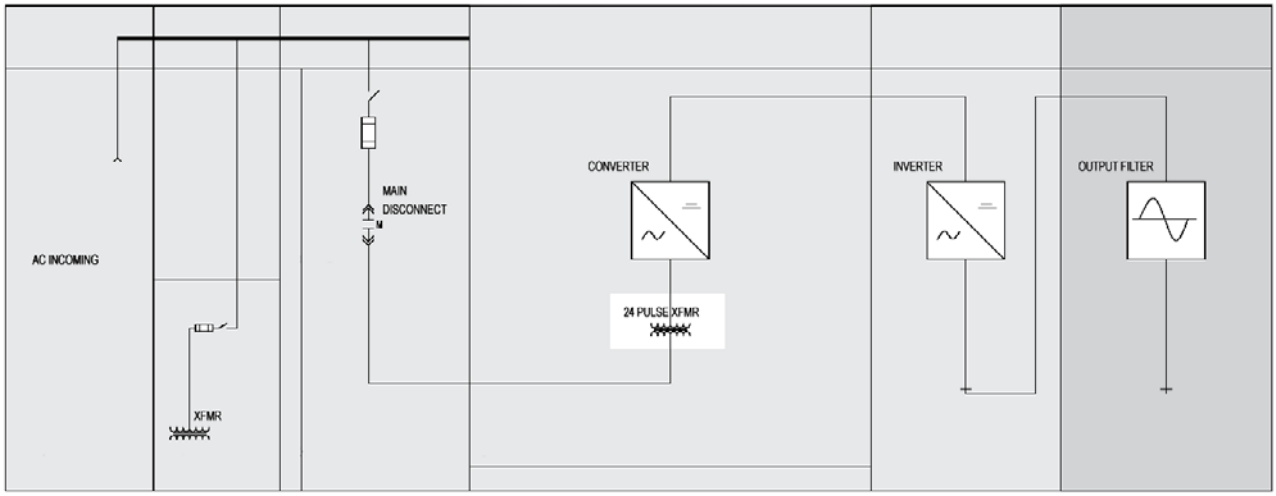


Figure 79. Sine Filter Power Flow One-Line Diagram



Figures 80 and **81** show installed Sine Filters in two frame sizes.

Figure 80. Sine Filter with Filter Fans Shown

Figure 81. Frame D Sine Filter

When to Apply a Sine Filter

Deciding to apply a Sine Filter depends upon several design factors. The length of the cable between the drive and motor; whether there is concern for motor heating due to additional harmonics; the motor design (inverter duty versus non-inverter duty), all play a role in the application decision. If the cable length from drive to a standard motor **or** to an inverter duty motor is greater than 1250 feet, apply a Sine Filter.

Sine Filter Ratings

The connected motor horsepower and current determine which SC9000 EP Sine Filter to apply. **Tables 27** and **28** show the filter catalogue numbers along with corresponding induction motor ratings. Contact the factory for synchronous motor applications.

Table 27. 2400V Sine Filters for Induction Motors

Catalog Number 39C2022	Motor Power (HP)	Filter Output (A)	Cabinet Size (H x W x D)	Watts Loss (W)
G02	350	82	92 x 40 x 50	1492
G04	450	104	92 x 40 x 50	1759
G06	600	135	92 x 40 x 50	2151
G08	800	178	92 x 40 x 50	2628
G10	1000	223	92 x 40 x 50	3142
G11	1250	279	92 x 40 x 50	3720
G12	1500	335	92 x 40 x 50	4013
G14	2000	446	92 x 40 x 50	5043
G16	2500	558	92 x 40 x 50	6327

Table 28. 4160V Sine Filters for Induction Motors

Catalog Number 39C2022	Motor Power (HP)	Filter Output (A)	Cabinet Size (H x W x D	Watts Loss (W)
G22	350	47	92 x 40 x 50	1530
G24	450	60	92 x 40 x 50	1792
G26	600	77	92 x 40 x 50	2199
G28	800	103	92 x 40 x 50	2708
G30	1000	128	92 x 40 x 50	3245
G31	1250	162	92 x 40 x 50	3860
G32	1500	186	92 x 40 x 50	4123
G34	2000	250	92 x 40 x 50	5204
G36	2500	312	92 x 40 x 50	6495
G38	3000	380	92 x 40 x 50	8375
G39	3500	434	92 x 40 x 50	9152
G40	4250	533	92 x 40 x 50	11315
G41	5000	624	92 x 40 x 50	13131
G42	6000	747	92 x 40 x 50	15212

Cooling Requirements and Filter Monitoring

Sine Filters are power components and require cooling to operate properly. Each Sine Filter cabinet is equipped with cooling fans and inlet air filters to provide satisfactory cooling. The Sine Filter reactors are also equipped with over-temperature switches and the capacitors have over-pressure switches to detect adverse conditions.

Maintenance

Sine Filter maintenance consists of periodic inspections of the cooling air fans and inlet air filters, and periodic checks of the oil-filled capacitors.

Inspect the cooling fans and inlet air filters at least once every three months. Clean the filters with an air jet and dust the fans to prevent dust buildup in the fan motor and bearings. Replace fans every three to five years.

Check the capacitors annually.

SC9000 EP Application Programming

CAUTION

Do not attempt to perform an SC9000 EP motor characteristics identification procedure with the sine filter connected between the SC9000 EP and the motor. this could damage to the SC9000 EP and require repair.

CAUTION

Do not use the Open Loop Vector Control mode with a Sine Filter installed. The Sine Filter will interfere with the SC9000 EP motor model calculations, resulting in improper operation.

Applying a Sine Filter to the SC9000 EP requires programming the Medium Voltage Drives Application. The Sine Filter introduces a voltage drop in the output to the motor. The SC9000 EP application programming raises the drive output voltage to restore full voltage performance at the motor.

Refer to Chapter 5, Parameter Group G1.14 for detailed information about the Sine Filter parameters.

The Sine Filter affects the choice of SC9000 EP operating modes. Refer to the Caution messages above for important restrictions.

Troubleshooting

The Sine Filter includes reactor thermal and capacitor pressure switches. When a Sine Filter is included in the SC9000 EP, these sensors connect to the SC9000 EP I/O and the drive application is programmed to monitor them. Detection of a thermal switch or capacitor pressure switch opening causes a drive shutdown and a fault message to be displayed and recorded.

Replacement Parts

Table 29 shows replacement part.

Table 29. Replacement Parts

Part Number	Description
W2E250-HJ32-0	Fan, WE250, 1P, 115V, 60HZ, 50C C
478C779H01	Intake Filter
Contact Eaton for Project-specific part	Capacitor Assembly (Overtemperature, Overpressure Switches Included)

O&M Technical References

For additional information about the SC9000 EP, refer to this SC9000 EP User Manual, IB02004001E.

Chapter 4: Synchronous Transfer

Purpose

With additional equipment, the SC9000 EP can provide synchronous transfer control to a multi-motor system. For any number of motors, this system individually starts and accelerates each motor and runs it at any desired speed. Or, it can start a motor, match the motor's voltage, frequency and phase angle to a utility power bus, and transfer the motor from the SC9000 EP to the utility bus.
The Synchronous Transfer system can also transfer any connected motor's power from the utility bus back to the SC9000 EP and individually control its speed or stop it.

Components

To perform this function, the Synchronous Transfer System must have an SC9000 EP output damping reactor, a PLC control system to receive customer commands, and bypass and motor select contactors for each motor. Customer commands include Start or Stop, Sync Up or Sync Down, for each system motor. The SC9000 EP can also include an optional AFD feeder bus contactor.

SC9000 EP Output Reactor

Sized for the SC9000 EP drive and motors' rating, the output reactor dampens current transients during the bypass contactor and motor select contactor switching.

Bypass Contactor

This Ampgard Medium Voltage starter assembly connects a selected motor to the Utility Feed Line upon command. There is one Bypass Contactor module for each connected motor.

Motor Select Contactor

This Ampgard Medium Voltage starter assembly connects a selected motor to the AFD Feeder Bus upon command. There is one Motor Select Contactor module for each connected motor. Unlike the Bypass Contactor module, this module does not include motor starter fuses, since the SC9000 EP provides overload protection.

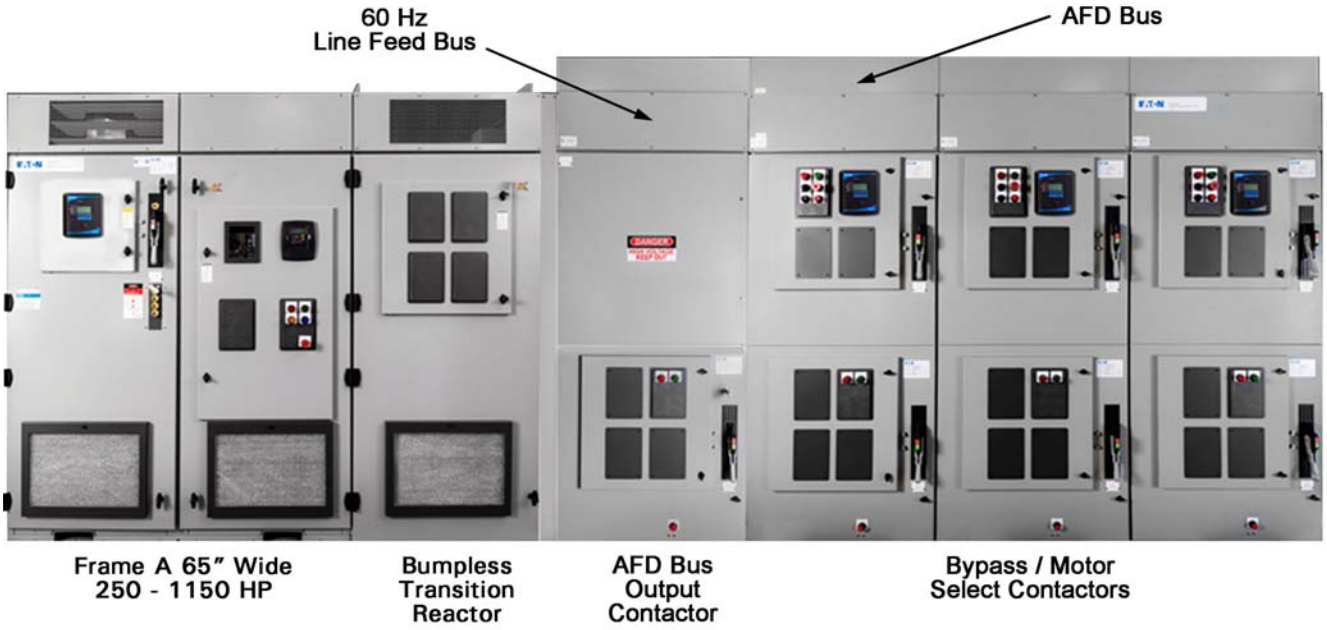
PLC System

The SC9000 EP Synchronous Transfer system includes programmable controllers to receive command inputs from the customer's supervisory control and sequence the SC9000 EP, the Motor Select and Bypass contactors. A Drive master PLC mounts behind a low voltage door in an SC9000 EP cabinet. Smaller PLCs for each motor in the system provide system scalability plus status monitoring for each system motor.

The Drive master PLC receives requests from individual motor PLCs for transfer operations. The master PLC checks system permissives and system status before initiating a transfer sequence.

The master PLC sequences and monitors each motor's Bypass Contactor, Motor Select Contactor and motor status to assure that proper execution of drive operation and contactor switching take place. Since a successful transfer includes voltage, frequency and phase synchronization between the SC9000 EP and the utility bus, the drive times each transfer step to the millisecond.

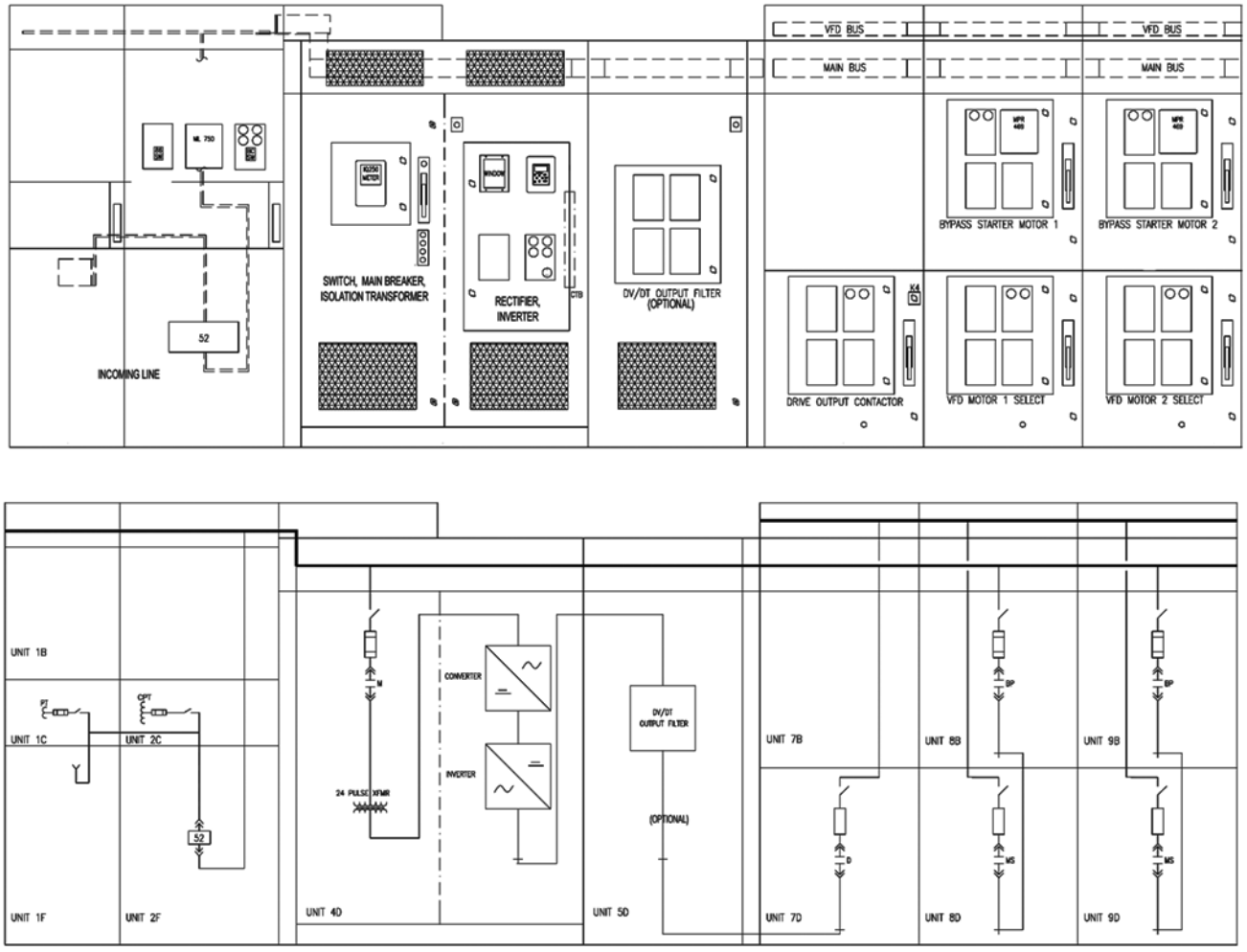
Figure 82. Synchronous Transfer



Synch Transfer Panel Layout and Power Flow

Figure 83 shows a typical Synchronous Transfer system panel layout and power flow.

Figure 83. Synchronous Transfer Panel Layout



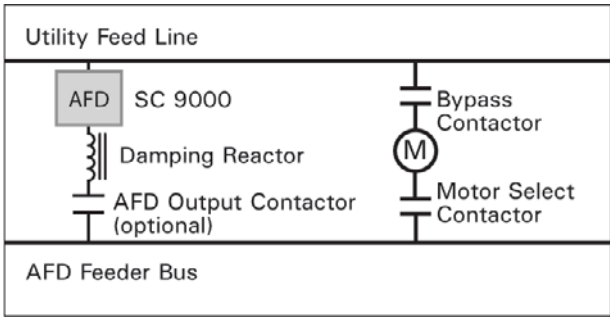
Transfer Control Operation

Following is a description of the Synchronous Transfer system operation. **Figure 84** shows the elements that make up an SC9000 EP Synchronous Transfer system.

Control Elements Colors and Symbols

■	= de-energized	■	= energized feeder bus
■	= energized AFD bus	≠	= contactor energized and closed

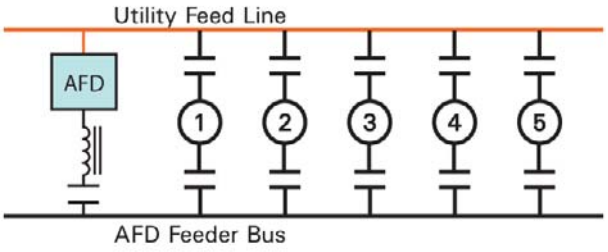
Figure 84. Synchronous Transfer Elements



Sequence of Operation

1. The AFD and Feeder Bus are energized (**Figure 85**).

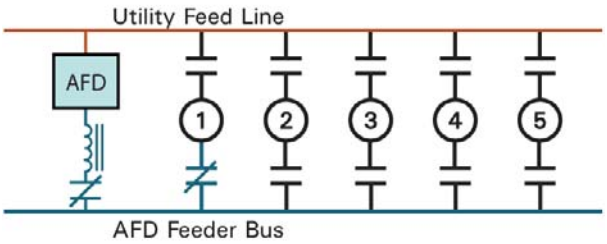
Figure 85. AFD and Feeder Bus Energized



2. The PLC receives a Start Command from the supervisory control system.

- The PLC closes the appropriate Motor Select Contactor
- When the Motor Select Contactor is closed, the PLC starts the AFD. The AFD accelerates and operates the selected motor at either a preset speed or a reference speed (**Figure 86**)

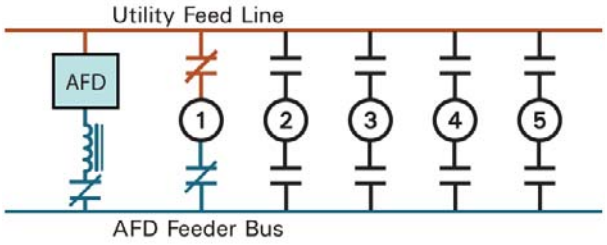
Figure 86. AFD Runs Selected Motor at Speed



3. Sync UP

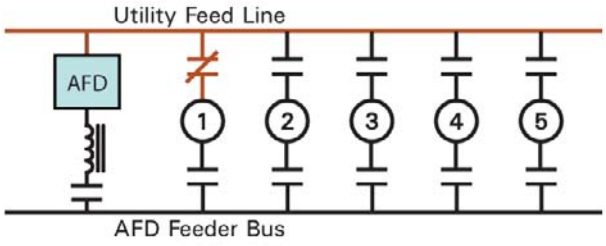
- When the motor is required to transfer to the utility line, the supervisory control instructs the PLC to send a "Sync Up" command to the AFD
- The AFD adjusts its output to match the utility line voltage, frequency and phase angle
- Once the AFD is synchronized with the utility line, the selected motor's bypass contactor closes, connecting the motor to the utility line, and the selected motor's select contactor opens, disconnecting the motor from the AFD bus (**Figure 87**)

Figure 87. Selected Motor Contactors Switching



- The AFD output reactor dampens any transient currents that may occur during the transition
- Once the transition is complete, the AFD shuts down and waits for another Start command from the PLC
- Now only the utility bus feeds the selected motor (**Figure 88**)

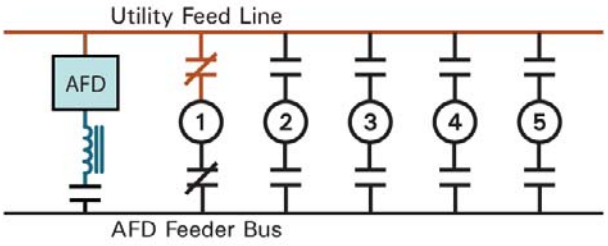
Figure 88. Selected Motor on Utility Bus



4. Sync Down

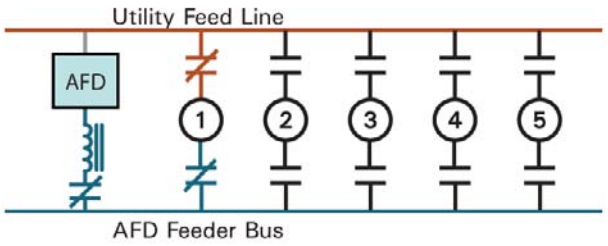
- When instructed by the supervisory control, the PLC sends a command to the AFD to "Sync Down"
- The PLC commands the AFD to start
- With the AFD output contactor open and the selected motor's bypass contactor closed, the PLC closes the selected motor's motor select contactor (**Figure 89**)

Figure 89. Motor Select Contactor Closes



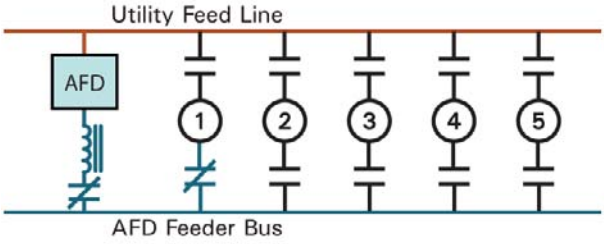
- The AFD is commanded to match the utility's voltage, frequency and phase angle; once this is completed, the AFD output contactor closes and the selected motor's utility's bypass contactor opens. The AFD output reactor dampens any transient currents that may occur during the transition (**Figure 90**)

Figure 90. AFD Contactor Closes, Bypass Opens



- The AFD, now connected to the selected motor, operates at a set speed or follows a reference speed (**Figure 91**)

Figure 91. Selected Motor Runs on AFD Bus



Control Interface

Customer commands for each motor include Start, Stop, Sync Up, Sync Down, and Run Speed. Motor and Contactor status are available for supervisory control.

Control Options

The SC9000 EP Synchronous Transfer system comes standard with Eaton Programmable Controllers. Other controllers can be furnished as an option.

Control Application Configuration

The SC9000 EP Medium Voltage Drives application has programming parameters for use with Synchronous Transfer systems. Refer to Chapter 5, Parameter Group G1.17 for detailed information on these parameters.

Fault Conditions / Alarm States

The SC9000 EP monitors fault conditions and alarm states for all Synchronous Transfer system elements. Individual motor PLCs monitor motor and contactors' status and coordinate with the Drive master PLC at all times. Drive status and alarm conditions are available through the SC9000 EP operator interface and remote supervisory control interface provisions.

O&M Technical References

For additional information about the Synchronous Transfer system elements, refer to this SC9000 EP User Manual, IB02004001E and your project O&M Manual references:

AD02004001E Synchronous Transfer Control with SC9000 EP

Chapter 5: Synchronous Motor System

Synchronous Motors

Synchronous motors are like other induction motors in that they have stator windings that induce currents and magnetic fields in rotor squirrel cage bars. In the synchronous motor, these squirrel cage bars, or *amortisseur* windings, are short-time rated, for starting duty. The synchronous motor also has externally-powered wound rotor magnets. How the wound rotor magnets receive their power defines the two synchronous motor types.

Synchronous motors come in two varieties: brush-type and brushless. The brush-type motor uses slip rings and brushes to conduct DC excitation current to the rotor wound electromagnets. The brushless type uses a separate set of stator windings and rotor bars to transmit AC to rotor-mounted hardware for conversion to DC.

Synchronous Motor Components

Figure 92, **Figure 93** and **Figure 94** show the essential rotor DC excitation components of Brush-type and Brushless synchronous motors.

Figure 92. Brush-type Synchronous Motor Elements

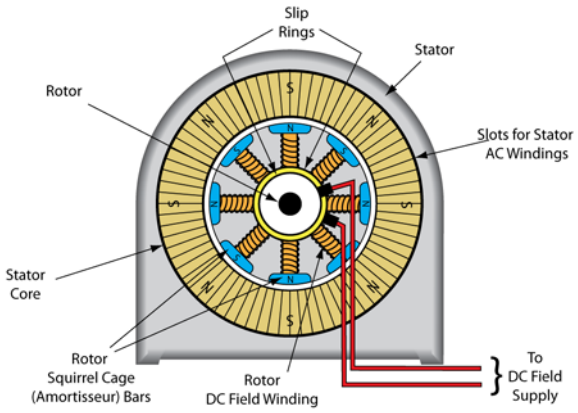


Figure 93. Brush-type Motor Slip Rings

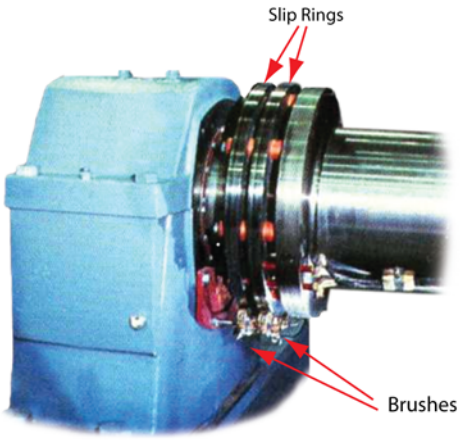
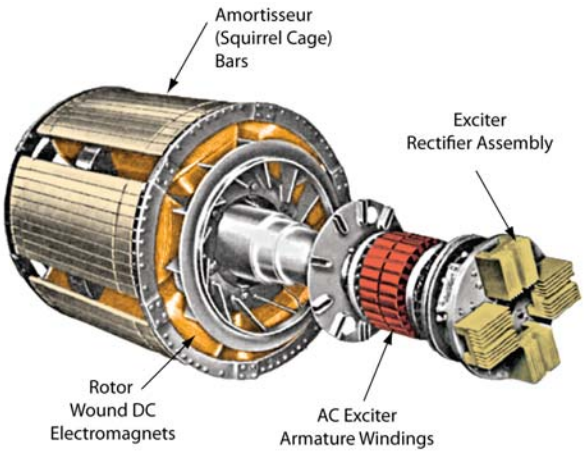


Figure 94. Brushless Synchronous Motor Elements



Note: Colors added for emphasis

A synchronous motor starts like a conventional induction motor, using a motor starter or VFD and relying on the torque produced by the stator magnets and squirrel cage bar magnets for acceleration. As the motor speed approaches its synchronous speed, an external control system detects this and energizes the rotor's separate-excitation windings, the wound electromagnets, pulling the rotor up to synchronous, or rated speed. Once at synchronous speed, the amortisseur windings act as damping windings to discourage motor speed variation, or hunting.

The brushless type synchronous motor has distinct advantages over the brush-type. Maintenance of the brushless type is considerably simpler. The brushless type does not require cleaning the slip ring collector, repairing damaged or corroded slip rings, inspecting and replacing worn brushes, etc. In addition, brush particles abraded from the brushes and loose in the motor frame can deposit on the motor windings, affecting insulation life.

In addition, the brushless type is more suitable for use in adverse environmental conditions. Maintaining slip rings and brushes under conditions like those found in chemical plants, where steam, oil or corrosive gases are present, is very difficult. Brushless motors designs for pressurized or explosion-proof requirements are much simpler than with slip rings and brushes.

The SC9000 EP drive system can include control and excitation for brushless synchronous motors.

SC9000 EP Synchronous Motor Control

The SC9000 EP Synchronous Motor control system provides both stator and rotor control and power. The SC9000 EP Adjustable Frequency Drive powers and protects the synchronous motor's stator windings, while the separate power and protection system provides the rotor windings excitation. **Figure 95** shows the SC9000 EP functional block diagram for brushless synchronous motors.

The SC9000 EP directs the field exciter, based upon configuration and settings parameters established in the drive application software. For more information about the application parameters, see Chapter 5, Parameter Group G1.15, which includes parameters for enabling or disabling the control, choosing control modes, setting control loop constants, and so on.

Brush-type Synchronous Motor Control

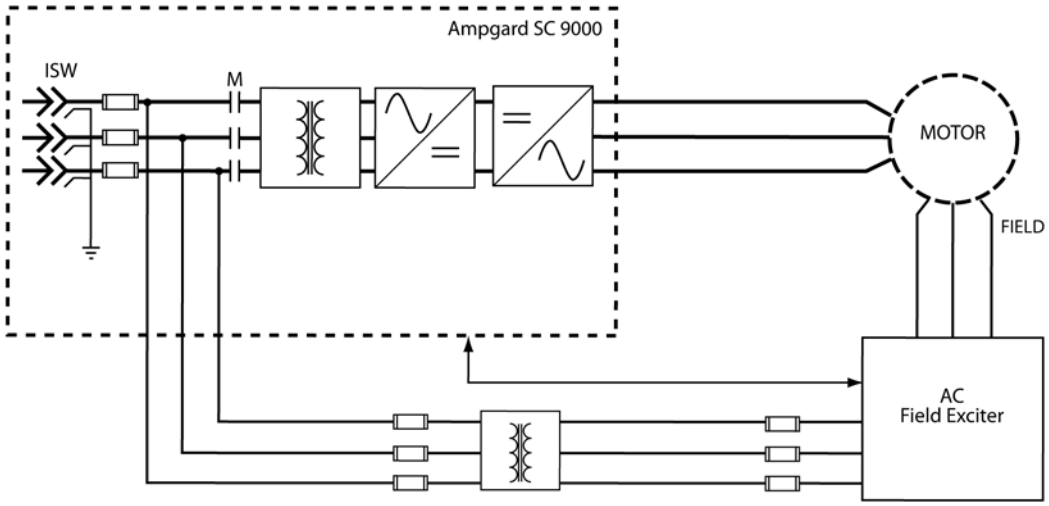
Although the SC9000 EP Synchronous Motor Control system is designed for brushless synchronous motors, Eaton also offers control systems for brush-type motors, powered by Ampgard Medium Voltage Starters. For more information about these systems, refer to Eaton IB 48045, Instructions for Mark VI Solid-State, Brush-Type, Synchronous Motor Controllers.

O&M Technical References

For detailed information on your Synchronous Motor control system, refer to the O&M manual, publications:

IB48045 Instructions For Ampgard® Mark 5.5 Solid-State, Brush-Type, Synchronous Motor Controllers

Figure 95. SC9000 EP Brushless Synchronous Motor Control



Chapter 6: High Voltage Input

Purpose

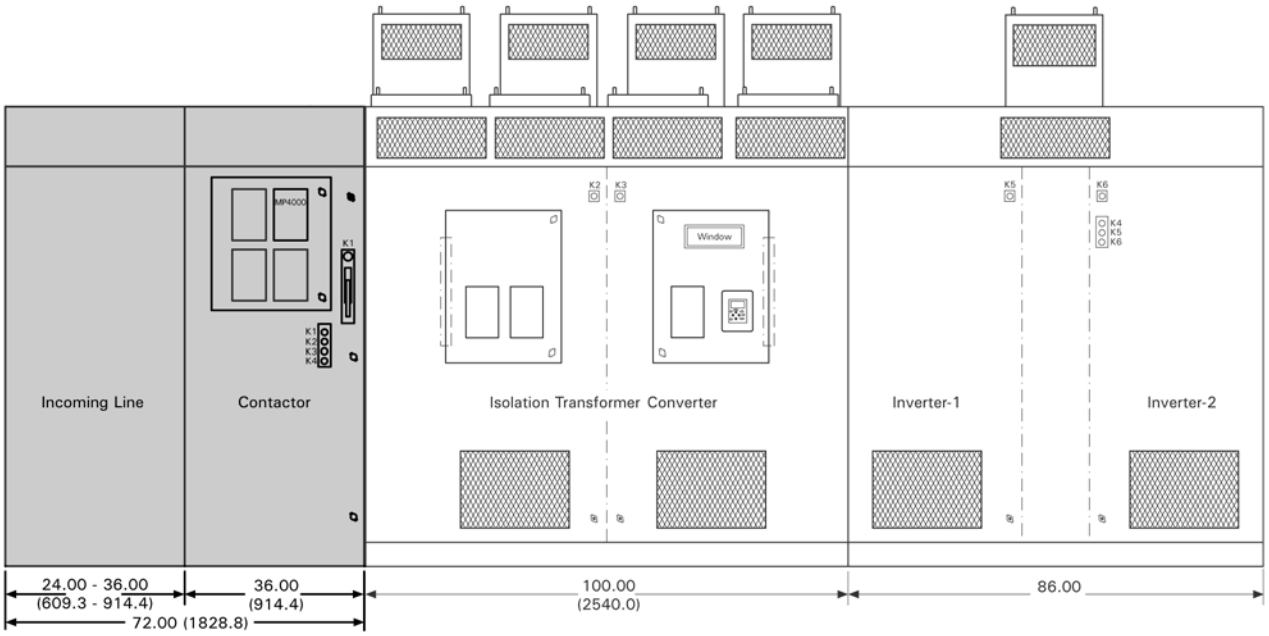
The SC9000 EP can deliver 2400V, 3300V or 4160V output voltages, and can accept input voltages between 2.4 kV and 13.8 kV. When the source voltage is above 6.9 kV, the SC9000 EP must include an additional 72-inch wide cabinet grouping. This grouping houses a 95 kV BIL incoming line termination array and a 15 kV input vacuum contactor starter. The SC9000 EP 24 pulse isolation transformer primary and secondary windings are also chosen according to the project input and output voltage requirements.

Contactor

The Ampgard Type SL, 300A, 15 kV vacuum contactor can be applied at voltages up to 13,800V and is rated to drive up to a 7500 hp induction motor (300 AFL).

Representative Mechanical Diagrams

Figure 96. 15 kV Input Voltage Panel Layout

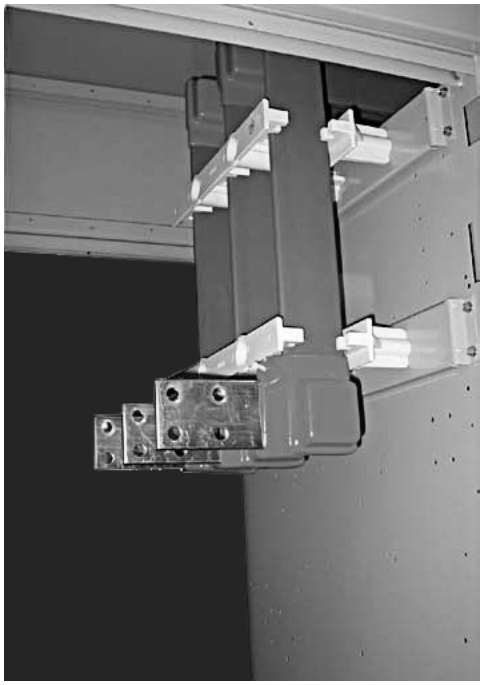


Representative Photos

Figure 97 shows a High Voltage Input incoming compartment. **Figure 98** shows a detail of the incoming cable termination points.

Figure 97. High Voltage Incoming Compartment

Figure 98. Incoming Cable Terminations



O&M Technical References

For additional information about the High Voltage Input system elements, refer to your project O&M Manual references:

IB 48050 Instructions for Installation, Operation, and Maintenance of the AMPGARD 15 kV, 300A Vacuum Starter

IB 48051 Instructions for Installation, Operation, and Maintenance of the SL 15 kV, 300A Vacuum Contactor

Chapter 7: Bypass System

Purpose

Bypass control provides for those times when an SC9000 EP AFD is taken offline and the connected motor must run. This chapter addresses the Eaton SC9000 EP bypass control products.

Types of SC9000 EP Bypass

There are two types of bypass control generally applied with SC9000 EP products:

- Full Voltage Bypass
- RVSS Bypass

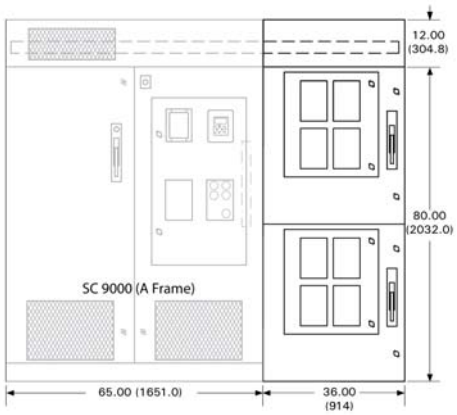
Full Voltage Bypass

This system switches an induction motor's power source between two sources: a utility source and an SC9000 EP AFD. Use Full Voltage Bypass when the AFD requires maintenance or troubleshooting. It allows the motor to connect to the incoming line, bypassing the AFD and performing a full-voltage start.

The motor and connected equipment must be able to tolerate an across-the-line start without mechanical or electrical damage. Fan or pump applications are examples of systems where a full-voltage start can work without connected equipment damage.

Representative Panel Layout Diagram

Figure 99. Representative Full Voltage Bypass Panel Layout



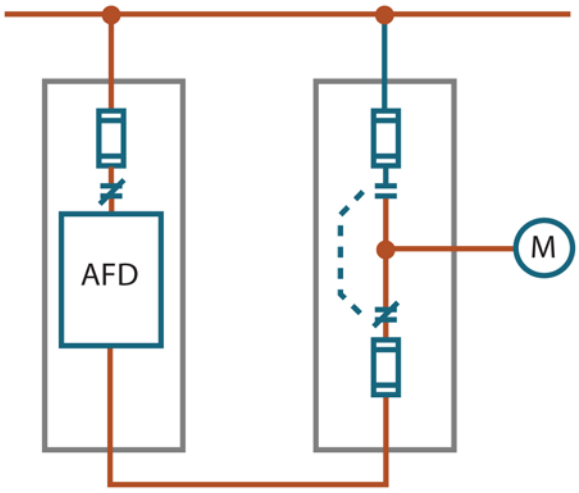
Sequence of Operation

Control Elements Colors and Symbols

■	= de-energized	■	= energized feeder bus
≠	= contactor closed		

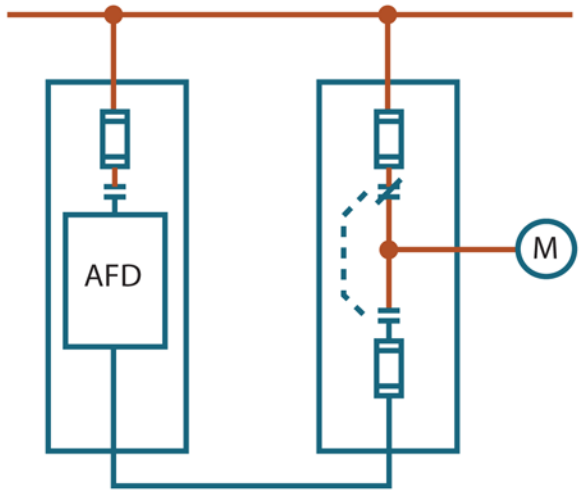
Under normal conditions, the SC9000 EP powers the motor, and the bypass contactor is open, isolating the motor from the AC power feed bus.

Figure 100. Normal Operation using SC9000 EP AFD



When the AFD is not available, the AFD input contactor is open, the Bypass Contactor AC line feeder contactor closes, the AFD output contactor opens, and the AC line feeds the motor.

Figure 101. Full Voltage Bypass Operation



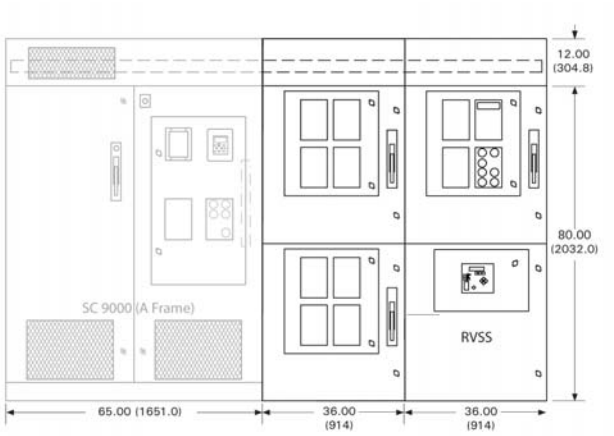
RVSS Bypass

When the connected mechanical equipment cannot tolerate a full-voltage bypass start, Reduced Voltage Solid State Bypass can provide bypass functionality while delivering a smoother, softer motor start. This can eliminate high motor inrush currents and connected load mechanical stresses. In addition, RVSS is easier on the electrical supply system, softening the burden during the motor start.

This bypass method works well on conveyors, PD pumps or systems where supplied voltage is limited. **Figure 102** shows a typical RVSS cabinet.

Figure 102. Typical RVSS Cabinet

Figure 103. Representative RVSS Bypass Panel Layout



Sequence of Operation

Control Elements Colors and Symbols

■	= de-energized	■	= energized bus
≠	= energized contactor closed		

Under normal operation, the SC9000 EP is operating and providing power to the connected motor. The Bypass contactor is in the non-bypass position, with power from the Reduced Voltage Soft Start system not connected to the motor through the Bypass Contactor.

Figure 104. RVSS Bypass Normal Operation

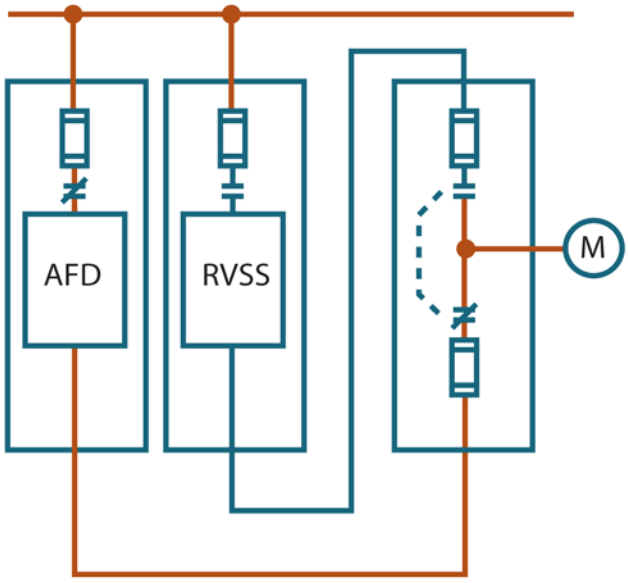
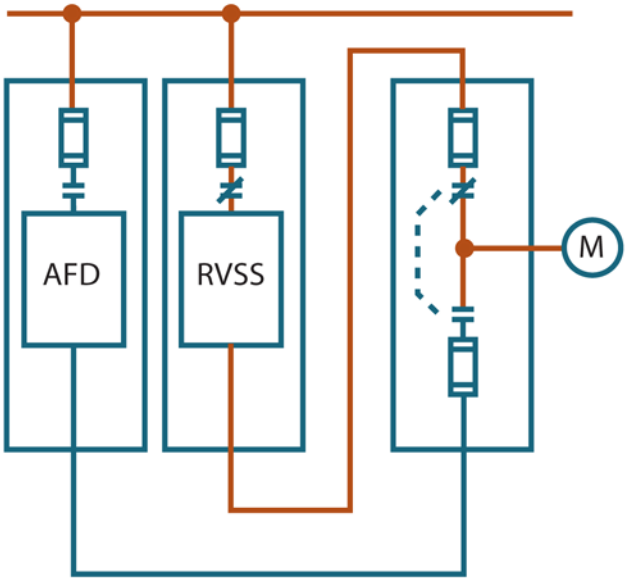


Figure 105. RVSS Bypass System Bypassed



O&M Technical References

For detailed information on your Bypass Control system, refer to the O&M manual, publications:

DEH41021	Medium Voltage Solid State OEM Soft Starter Installation and Operation Manual
IB 48041	Instructions for AMPGARD 400A Medium Voltage Starter

Eaton is dedicated to ensuring that reliable, efficient and safe power is available when it's needed most. With unparalleled knowledge of electrical power management across industries, experts at Eaton deliver customized, integrated solutions to solve our customers' most critical challenges.

Our focus is on delivering the right solution for the application. But, decision makers demand more than just innovative products. They turn to Eaton for an unwavering commitment to personal support that makes customer success a top priority. For more information, **visit www.eaton.com/electrical.**

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